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THE DIAGNOSIS AND TREATMENT OF BENIGN AND MALIGNANT TUMORS OF BONE*

JOSEPH COLT BLOODGOOD
Baltimore

Utimate Results. This personal study of 240 cases of bone tumors observed over a period of about twenty-seven years, brings out the fact that the probabilities of a permanent cure, even after high amputation, for the true periosteal and central sarcoma of bone is so small that, when one is confronted with a bone lesion, one should not perform any radical operation until every possible means of diagnosis has been employed. The burden of proof is to demonstrate that the lesion is malignant.

Results in Periosteal Sarcoma. Up to the present time there are but two cures (less than 4 per cent.) among the cases followed. These may be summarized as follows:

Total of cases	70
Cured 5 years	2
Lived 3 years	1
Lived 2 years	3
Lived 1 year	6
Lived less than 1 year	36
Postoperative deaths	3
Lost track of	18
Dead of other causes	1

This demonstrates that the average duration of life in a periosteal sarcoma is one year or less—42 out of 52 cases followed. The cause of death in periosteal sarcoma is metastasis to the lung, and not local recurrence.

Metastasis to the Lung in Periosteal Sarcoma. The ob-

*Paper read before the Omaha Roentgenological Society, March 27, 1920, at Omaha, Nebraska. Illustrations by Mr. Herman Schapiro.

servation in which this has taken place in the shortest period after the first symptoms of the local growth has just been brought to my attention by Dr. H. H. Donaldson of Pittsburg, Pa.

The patient is a white female, aged ten years; the symptoms had been present but four weeks (pain four weeks; swelling one week) before the patient came under observation, and an *x*-ray demonstrated a periosteal sarcoma of the shaft of the femur extending from condyle to within 2 inches of the greater trochanter. About two weeks later (six weeks after the onset) an *x*-ray of the chest showed extensive metastasis to the lung.

A second case was brought to my attention in Omaha by Dr. R. L. Smith in which the *x*-ray of the chest within a few months after the first symptoms showed extensive metastasis. Pathol. No. 25888. (Figs. 87 and 88.)

In every bone tumor, therefore, *an x-ray of the chest* should be a routine procedure, but in a number of cases under my observation, in periosteal sarcoma, the picture of the chest at the time of operation was negative, and metastasis to the lung was not observed until later—in one case not until two years after operation. This must be looked upon as evidence that metastasis was present, but not evident, in the x-ray picture.

Cured Cases of Periosteal Sarcoma. Two cases—less than 4 per cent.

Pathol. No. 14143 (ix). Patient of Dr. Twinch of Newark, N. J. White female, aged 11 years; swelling of upper third of tibia 6 weeks; *x*-ray—periosteal sarcoma of upper third of tibia with much new periosteal bone formation and very little bone destruction. First operation—excision of piece for diagnosis by Dr. Twinch; microscopic diagnosis (Bloodgood): Mixed spindle-and-round-cell sarcoma, with numerous giant mononuclear cells and many giant cells of the giant-cell tumor, or epulis type. Amputation advised and performed in 1913. The patient is well (1920) seven years since operation.

There is apparently no question in this case that the tumor belonged to the most malignant type of sarcoma. We find the giant mononuclear cells only in the very malignant sarcomas, in 21 cases: 14 periosteal and 7 central.

The presence of giant cells (of the giant-cell tumor, or epulis type) in periosteal and central sarcoma apparently does not affect the prognosis. I have noted them in 15 cases: 5 periosteal and 10 central.

Pathol. No. 14392. (ix) Amputation of upper femur by Dr. Follis, Johns Hopkins Hospital in 1913. Patient well September, 1919, six years and two months. White female aged twenty-four. Pain and swelling above knee one year and six months. Clinical picture and *x*-ray typical of a periosteal sarcoma. The gross specimen shows that the lower half of the femur is surrounded by a periosteal tumor with a pathological fracture at the epiphysis. Microscopically, it is a small-round-cell sarcoma.

I have observed 9 cases of small-round-cell sarcoma. All of them were periosteal lesions. This is the only cured case.

There is nothing in these two cases of periosteal sarcoma to distinguish them from the 50 cases in which the patients ultimately died of the disease. In the first case (Pathol. No. 14143) the patient was young (11 years), the amputation early after the symptom of onset (7 or 8 weeks), and in this case a piece had been excised for diagnosis. In the second case (Pathol. No. 14392) the patient was older (24 years), and the amputation 18 months after the symptom of onset. So it may be considered a late intervention. Neither of these cases had any other treatment, except amputation. Therefore we must look upon these cures as accidental, but they do establish the fact that now and then the most malignant periosteal sarcoma may remain a local lesion and such patients are cured by the removal of this lesion.

Results in Central Sarcoma. Up to the present time there are 2 five-year cures, which is about 10 per cent. of the total of followed cases (19). Of these two cures one is still living

(April, 1920) six years and ten months after amputation of the femur for a central sarcoma of the lower end of the femur of the malignant hemorrhagic cyst type. The second case is dead nine years after operation with recurrence in the chest wall and metastasis to the lungs.

The results may be summarized as follows:

Total of cases		25
Cured 5 years	2	
Lived 4 years	1	
Lived 2 years	2	
Lived 1 year	5	
Lived less than 1 year	8	
Postoperative death	1	19
Lost track of	2	
Recent, living	4	

As compared with periosteal sarcoma the central sarcoma shows a little better prognosis, and, on the whole, the duration of life is longer.

Among the 4 recent cases which are living and apparently free from recurrence, in two it is three years since the operation, but, as noted above, one patient lived this long without signs of recurrence and then died with metastasis to the lung about four years after the operation.

Later, when I differentiate the types of periosteal and central sarcomas I will bring out the fact that the central sarcoma of the malignant hemorrhagic cyst type (called *bone aneurism* in the older literature) has shown the best results—33 per cent cured five years among six cases, and two recent cases apparently well three years.

Cured Cases of Central Sarcoma. (Both Malignant Bone Cysts.) It is important to note here that for comparison I have considered a patient cured when five years after operation there were no signs of recurrence. Of four five-year cures of periosteal and central sarcoma three are living and apparently free from recurrence today, and one is dead nine years after operation. This demonstrates that late

recurrences, very unusual in sarcoma of bone, may take place.

Pathol. No. 10602. (XIII.) Fig. 26. Central sarcoma of the shaft of the humerus, of the malignant hemorrhagic-cystic type.

The patient was first observed by Drs. Finney and Fisher of Baltimore in 1910. White male, aged thirty. Pain after contusion of the arm two years ago. This pain has continued. Five months before Dr. Finney's operation, fracture at the junction of the middle and upper third of the humerus. The *x*-ray taken at this time shows the fracture, but the tumor was not noted. I had a recent opportunity to restudy this *x*-ray, and I find a definite central shadow at the site of the fracture, and am of the opinion that the fracture was a pathological one. About one month after this fracture swelling was observed, and the *x*-ray shows a more definite central area (Fig. 26). Operation August 23, 1910, by Dr. Finney,—curetting. October 10, 1910, second curetting. Then treatment by Dr. Coley of New York with serum. January, 1911, four months after the first curetting, amputation at shoulder-joint by Dr. Coley. Serum treatment continued. One year later, January, 1912, removal of a metastatic mass in the axilla. Serum treatment continued. Two months later, March, 1912, shoulder-girdle amputation by Dr. Fisher of Baltimore, because of recurrence. This patient remained well and free from recurrence to January, 1919, almost seven years after the last amputation and nine years after the first curetting. Then there was observed local recurrence in the scar of the axillary stump and metastasis to the lung.

I saw this patient on a number of occasions, and he was perfectly well and able to be active in mercantile life for a period of almost seven years.

When Dr. Finney curetted in 1910, as far as I can ascertain, the bony shell was intact except at the site of the pathological fracture. There was not much expansion of the bony shell. The cavity was filled with blood and soft,

friable, hemorrhagic tumor tissue, resembling in the gross the giant-cell tumor. When this tissue was received in the laboratory I was of the opinion that it was a giant-cell tumor. But the frozen sections showed no giant cells, but a mixed spindle-and-round-cell sarcoma. Microscopically, there was no question as to the malignancy of the tumor.

At that time, now almost ten years ago, Drs. Finney and Dr. Coley decided to try the serum before amputation. I was rather inclined to the conclusion that resection of the humerus with bone transplantation, or shoulder-joint amputation, promised the patient a better chance of an ultimate cure. The long duration of life in this case may be explained by the serum, but the patient's arm was not saved and it could have been amputated in August, 1910, instead of in January, 1911, four months later.

If this case came under observation today, we could conclude that his age (30 years) would exclude a bone cyst. Bone cysts (Fig. 27) are very common in the shaft of the humerus, but all the patients have been under twenty, usually under fifteen. Up to the present time we have never observed a giant-cell tumor in the humerus as a central lesion. Therefore, one would have explored. Finding the blood after the removal of a piece of the bony shell, would have at once suggested the malignant bone cyst, and in this case the frozen section would have been easy to interpret, because of the absence of giant cells of the giant-cell tumor type. One, then, would have resected the humerus with its periosteum, giving the lesion a wide margin and transplanted into the defect a piece of the fibula.

There is nothing in this *x*-ray (Fig. 26), as we look at it today, to allow a differential diagnosis between a bone cyst, a giant-cell tumor, and a central sarcoma.

Pathol. No. 14229. (XIII) Figs. 20, 21. Amputation of the upper third of the femur in 1913. Patient well April, 1920, seven years. The tumor involved the lower end of the femur and condyle. It belonged to the type of the malignant hemorrhagic bone cyst. Microscopically, it was

a large spindle-and-round-cell sarcoma, with giant mononuclear cells and a few giant-cells of the giant-cell tumor type. That is, it resembled Pathol. No. 14143, a periosteal sarcoma of the upper third of the tibia, Dr. Twinch's case, which has remained well seven years after amputation.

This case of malignant hemorrhagic bone cyst (Heine) was a white female aged 61. For ten years she has had pain and tenderness in the left knee suggesting an arthritis, but no other joints were involved. There was no definite history of trauma. For two years there has been some flexion of the leg at the knee and partial fixation of the joint. As the patient was practically bedridden, there was no opportunity for a pathological fracture. This patient had been under the care of Drs. Baer, Baetjer and Penrose for one year. Their diagnosis had been chronic arthritis; treatment by fixation (plaster) was so painful that it had to be discontinued.

Dr. Penrose asked me to see this patient in 1913. The examination of the knee-joint suggested a chronic arthritis. No other joints were involved. The *x*-ray (Fig. 20) (14229) is a lateral view. I frankly confess that at that time (1913) I did not make a diagnosis of sarcoma, but was of the opinion that it was some form of chronic arthritis without any bone formation, or destruction of the articular surfaces.

Restudied more recently, the picture should have suggested a central lesion in the lower end of the femur. The most striking change is the lipomasia or osteoporosis of the tibia and fibula which could easily be explained by nonuse, but this is not present in the femur and its condyles. The portion of the inner condyle which we can see shows definite evidence of bone destruction and is not the picture of lipomasia. It is not unlike an *x*-ray of a bone cyst or giant-cell tumor. The shadow of the outer condyle is darker with a thin area above the epiphysis. This darker shadow can be explained by the overlapping of the two shadows of the condyles. The contrast between the shadow of the

tibia and fibula and that of the femur is against arthritis and favors a localized lesion in the lower end of the femur.

We now know that the most characteristic feature of the *x*-ray of a bone cyst, a central giant-cell tumor, or a central sarcoma, is the absence of new bone formation in the periosteum covering the expanded and thin shell present in this case.

The age of this patient—sixty-one (fifty-one at onset)—practically excludes a cyst, and the giant-cell tumor is rarely observed at this age, while the central sarcoma is not uncommon at this age. The *x*-ray of this case should be compared with Fig. 22 (P. No. 23881, Jarvis) which is an example of the changes in all the bones of the knee-joint in traumatic chronic arthritis of long duration associated with non-use.

Operation June 6, 1913. I first explored the knee-joint preparatory to a resection, to give the patient a stiff, painless limb. On opening the knee-joint and flexing, I saw a crack in the cartilage of the inner condyle near its junction with the outer. I had never seen this in arthritis. When I put a periosteal elevator in the crevice, there exuded blood. Then I felt convinced that I was dealing with a malignant bone cyst (bone aneurism). At that time I had observed four cases and had reported them in the *Annals of Surgery* for August, 1910, Figs. 39 to 43.

The wound was disinfected with carbolic acid followed by alcohol, and an amputation performed in the upper third of the thigh.

Gross Pathology. Fig. 21 (14229) is a longitudinal section through the lower end of the femur. The condyles are filled with blood and tumor tissue. There remains a capsule of cartilage and very thin bone. The shaft of the femur is also shown in the picture. Tumor tissue does not extend far up the marrow of the shaft. The crevice mentioned in the operative note can be seen in this picture.

When one looks at this specimen and then at the *x*-ray, one is surprised at the shadow produced by such a thin

bony shell. Perhaps the blood in the cavity may explain the dark areas.

If this patient had been able to walk, pathological fracture might have been expected.

Central Bone Lesions

Benign Bone Cysts (Ostitis Fibrosa)	54 cases
Central Giant-cell Tumors	50 cases
Chondroma, central	3 cases
Myxoma, central	8 cases
Central sarcoma	25 cases

Types of Central Sarcoma

Myxosarcoma	2 cases
Fibrosarcoma	4 cases
Various forms of cellular sarcoma	11 cases
Malignant bone cysts	8 cases

Myxoma. In my opinion this bone lesion, whether central or periosteal, should be classed with, and treated as, a sarcoma. The older pathologists wrote that the myxoma of bone is a benign tumor, but it always recurs. It is important, therefore, here to record the results in central myxomas.

Three cases of central myxoma, two involving a phalanx of the finger and one the shaft of the humerus, have remained well, but in these three cases tumor tissue was not exposed at operation, but the bone removed without exploratory incision by amputation (humerus, one finger) or by resection (one finger).

Two cases in which the central lesion was explored and the bone involved removed with the curette, recurred, one involving the astragalus (Fig. 28), one the os calcis. The latter is well two years after amputation and the other involving the astragalus (Figs. 28, 29, 30) recurred in the upper end of the tibia after amputation in the middle third of the tibia, and at the present time is well nine months after reamputation through the femur.

One patient died three months after an amputation at the

hip-joint for a central myxoma of the femur, and two patients with tumors involving the phalanx, have been lost track of.

As will be noted later, the results in periosteal myxoma are worse than in central myxomas, because in every instance the tumor was explored.

The danger in myxoma is the exploration of the tumor, because this tumor tissue, in my observation, is more transplantable on the same individual, than any form of normal or tumor tissue. This subject will be again discussed when we come to the exploratory operation.

The point that I wish to emphasize here is, that when the *x*-ray shows a central or marrow lesion, the probabilities are that it is benign, as 107 cases is to 31. If the central tumor proves to be a sarcoma, the chances of a cure by the complete removal of the local growth are less than 10 per cent.

We also must remember that now and then tuberculosis may produce a picture resembling a central benign or malignant tumor.

When one explores a central bone lesion, the most important thing to do first is to establish the diagnosis, and the myxoma requires special treatment.

Pathol. No. 22929. Central Myxoma of Astragalus (Figs. 28, 29, and 30.) This case will be given in brief, because the detailed description of the treatment of myxomas, central and periosteal, will have to be considered in a later paper.

The patient was a white male aged forty years, and the *x*-ray (Fig. 28) was taken in March, 1918. He complained of swelling of the ankle of two years' duration. But as there had been a previous history of gonorrhoea and infected tonsils, it was diagnosed arthritis. When the astragalus was explored, it was diagnosed giant-cell tumor. The patient came under my observation one year later with evidence of recurrence in the wound left by the removal of the astragalus piecemeal. I amputated the leg in the lower

third. Fig. 29 shows the gross specimen of the recurrent myxomatous tumor. *X*-rays of the remaining bones of this extremity after the amputation were negative. The patient returned in five months because of pain and tenderness in the region of the tubercle of the tibia (Fig. 30). I explored this area with the cautery, found the myxoma, and amputated above the knee-joint. This patient is apparently well (June, 1920) nine months after last operation. Sections from the original tumor in the astragalus and both recurrent tumors show pure myxoma. (Compare with Figs. 56, 58, and 59.)

Clinical Picture of Central Bone Tumors. The study of these 240 cases as to age of onset, duration of symptoms, symptoms of onset, such as pain, pathological fracture, swelling, disturbance of function, history of fracture and history of trauma, often leads to a pretty accurate diagnosis. When we come to the examination the two most important data, exclusive of the *x*-ray, are the blood Wassermann and the presence or absence of the Bence-Jones bodies in the urine.

In all bone lesions there should be, in addition to the *x*-ray of the affected bone, *x*-rays of other bones and of the chest.

In all adults the possibility that the bone lesion is metastatic should always be borne in mind, notwithstanding the fact that only one bone shows involvement.

Age of Onset. This is computed by subtraction of the duration of the disease since the symptom of onset from the age of the patient at the time of observation. In the majority of cases of bone tumors swelling appears so rapidly, even when it is not the symptom of onset, that it is not difficult to compute the duration of symptoms. But when there is the history of a fracture which has healed, or of localized pain months or years before swelling is noted, the question naturally arises, Shall we look upon the history of a fracture or localized pain as evidence that the disease was present at that time? In my table I have done this.

Age of Onset Ten Years or Less. Twenty cases:

Bone Cysts	16 cases
Giant-cell Tumors	3 cases
Myxoma	1 case

The patient with myxoma, who at the age of onset was under ten, had had swelling for twenty-eight years following a trauma. The tumor involved the phalanx of the first finger. The bone capsule was involved. In this case the long duration would be very unusual for a cyst or giant-cell tumor, and the most common central tumor in a phalanx is a myxoma.

It is important to remember that the giant-cell tumor has been observed in children under ten years of age. As the differential diagnosis between the cyst and giant-cell tumor is by no means always possible, and as we know that the cyst may heal spontaneously, the question is, Shall operation be performed at once, in order to establish the diagnosis and curet the giant-cell tumor early, or is there any danger in delay? I am inclined to the view that there is no danger. From my recent experience with bone cysts allowed to heal spontaneously, the subsequent *x*-ray pictures show very quickly evidence of ossification. Up to the present time, however, I have had no experience with delay in giant-cell tumors.

From our knowledge of the benignity of the giant-cell tumor I can see no danger from delay under *x*-ray observation.

From my experience up to date, the age of onset at ten years or younger, excludes a central sarcoma.

Giant Cell Tumors. Age of Onset Ten Years or Less.

Pathol. No. 6893. (V) Patient of Dr. G. G. Davis of Philadelphia. The patient was a white boy, aged two and a half years. Swelling of the lower end of the radius had been observed nine months. The *x*-ray (reported by Bloodgood, *Annals of Surgery,* August, 1910, Figs. 29, 30, and *Annals*

of Surgery, April, 1919, Fig. 20) shows a central shadow in the lower end of the radius with the involvement of the epiphysis; the bony shell is preserved. On the whole this *x*-ray is more like a cyst than the giant-cell tumor, because the light area is fairly uniform with absence of the irregular dark lines present in the giant-cell tumor. The case was immediately operated on by Dr. Davis and curetted in 1905. This patient is well (1920) fifteen years since operation. The *x*-ray of the result five years after operation shows restoration of the affected bone to normal (*Annals of Surgery,* August, 1910, Fig. 30).

Pathol. No. 12207. (V) Operator Dr. A. R. Kimpton of Boston. The patient is a white female aged five years. The symptom of onset was a fracture of the shaft of the tibia from a slight trauma sixteen months before operation. No *x*-rays were taken. Following the healing of the fracture swelling persisted with tenderness, but no marked pain. Because of the swelling an *x*-ray was taken (reproduced by Bloodgood, *Annals of Surgery,* August, 1912, Figs. 11 and 12). This showed a shadow in the upper third of the tibia beginning some distance below the upper epiphysis. The expansion is slight and the bony shell is quite thick; there is no new periosteal bone formation. This *x*-ray is different from any other bone cyst or giant-cell tumor which I have studied.

Dr. Kimpton in this case curetted in 1911 and then disinfected the cavity with Harrington's solution. There has been no recurrence (1920) nine years since operation.

Pathol. No. 17536. (V) Patient of Dr. McGill of Butte, Mont.

The lesion involved the marrow cavity of the end phalanx of the little toe. The patient was a white male aged eight years. There had been pain and swelling four months without the history of injury. The *x*-ray showed a small marrow shadow with the preservation of a bony shell. The toe was amputated. Up to the present time this is the only central lesion observed by me in the phalanx of a toe. All

the central lesions of the phalanges of the fingers have been myxomas (four cases). In this case the amputation could have been confined to the end phalanx.*

Should one explore for a definite central tumor when the age of onset is ten years or less? From the evidence up to date there is no apparent danger in delay. The probabilities are that the lesion is a bone cyst. If repeated *x*-ray studies do not show quickly evidence of ossification, then one should explore.

I now have three bone cysts in the shaft of the femur which were not operated on and which have completely ossified, similar to Colvin's case (Figs. 50 and 51). (See Transactions Medical Association of State of Alabama, Figs. 17 and 18.)

Age of Onset Ten to Fifteen Years. Thirteen cases:

Cysts	11 cases
Giant-cell tumors	1 case
Myxoma	1 case

The possibilities, therefore, at the ages between ten and fifteen are identical with those at ten and younger. Up to the present time we have no record of a central sarcoma at this age. The myxoma in this group was in a patient aged thirty when he came under observation, but claimed to have suffered with pain in the ankle since thirteen years of age—seventeen years.

Matthews of New York in the *Annals of Surgery* for August, 1903, reports a case of central giant-cell tumor in the mid-shaft of the tibia in a boy aged thirteen, in which there had been pain and swelling for two months. This patient is well seven years after curetting.

A case which I saw recently in consultation illustrates the fact that surgeons, roentgenologists and pathologists are not yet familiar with the importance of the easily available data as helps to diagnosis.

Pathol. No. 25656. The patient was a boy just fifteen years of age. The operation was six days after a frac-

*Recently two cases of central chondroma of the phalanx of a finger have been observed (July 10, 1920).

ture. The *x*-ray (Fig. 89) was taken immediately after the fracture. The fracture apparently followed a slight trauma. The *x*-ray showed the fracture in the middle of the shaft of the humerus, and in the center of the fracture a definite central or marrow shadow about 4 cm. in length. The lower portion of the central shadow was sharply marked off from the marrow below, but the upper was not clearly defined. There was no evident perforation of the bony shell, except at the crevices of the fracture which was slightly comminuted. In this case *x*-rays of other bones excluded other lesions. The *x*-ray of the chest was negative. The blood Wassermann was negative, and there were no Bence-Jones bodies in the urine. There was nothing in the *x*-ray, when studied alone, to differentiate between a myxoma, a chondroma, a cyst, a giant-cell tumor, or a central sarcoma.

Up to the present time I have recorded in my list* 10 examples of simple cysts, no giant-cell tumors, and five central sarcomas. All the central sarcomas were older, and none of those between the ages of sixteen and twenty were situated in the humerus.

On the theory of probabilities, therefore, the chances were that the lesion was a bone cyst.

As a symptom of onset pathological fracture is rarely recorded, except in the bone cyst, and here it is very common, especially in the shaft of the humerus and femur.

I have no evidence that fracture through a central giant-cell tumor leads to infiltration of the soft parts.

In this case there was great difference of opinions in the interpretation of the *x*-ray picture. I got the impression that the majority *feared* a central sarcoma.

The site of the fracture was explored under an Esmarch. The central shadow pictured in the *x*-ray was occupied by a solid mass of firm, opaque, white tissue, covered with some blood which could be easily explained by the recent fracture. The bony shell showed less expansion and was a little thicker than in the bone cysts upon which I had previously

*Of central lesions of the humerus.

operated, but I had never observed this lesion in such an early stage before. The gross appearance of this tissue shows a minute cyst 1 to 3 mm. in diameter, and a small red currant-jelly area. From the frozen section the pathologist was of the opinion that it was a myxosarcoma, but the microscopic picture, from my experience, resembled benign ostitis fibrosa.

The operator in this case decided to remove the tumor tissue, and not to resect nor to amputate, and then, giving the patient the benefit of any doubt, to employ radium treatment. It is now (June, 1920) four months since the operation, and from *x*-ray studies normal healing of the fracture has taken place.

This case illustrates the difference of opinion of experienced surgeons, roentgenologists and pathologists, on the clinical, *x*-ray, gross and microscopic diagnosis. This is due to the fact that no one has had a very large experience with these comparatively rare lesions, and no one as yet has presented and published a study of a large group of cases observed over a number of years in which the results are known. I am attempting to do this now.

I am inclined to think that longer observations will demonstrate that this patient belongs to the group of bone cysts in which the central, or marrow, cavity is filled with a solid mass of inflammatory tissue—a condition now called ostitis fibrosa.

Solid Ostitis Fibrosa. Up to the present time I have records of seven cases, two involving the shaft of the femur, three the shaft of the tibia, one the iliac bone, and in this case the shaft of the humerus.

The two cases involving the shaft of the femur have been previously reported in *Annals of Surgery* for August, 1910, where Figs. 5 and 7 illustrate the *x*-rays, and Fig. 8 the gross appearance. In these two cases the longitudinal involvement was longer than in the case just discussed. In both the symptom of onset was fracture. The age of onset was three years in one case and sixteen or eighteen in the

other. In one case the operation was four and one-half years after the first fracture for refracture, and in the other about five years after the first fracture for refracture and bending. Both patients have remained well after local removal of the disease, one ten years, the other sixteen years after operation. One of these patients was operated on by Dr. Halsted at the Johns Hopkins Hospital in 1904, and the other by Dr. Kammerer of New York in 1903. Dr. Kammerer was able to follow his case for ten years. These cases were again referred to in my paper before the Medical Association of the State of Alabama in April, 1919. (See Transactions.)

In 1916 Dr. Roche, Pathologist to St. Vincent's Hospital in Norfolk, Va., sent me a mass of tissue curetted from the center of the mid-shaft of the tibia of a female patient aged twenty-six, who had observed a swelling in this region for five years (since age of 21). Gross and microscopically, this tissue resembles that removed in Pathol. No. 25656. I advised against further operation beyond the first curetting, and this patient is well in 1920, four years. There was no pathological fracture in this case. The *x*-ray was not sent to me.

In February, 1919, Dr. Neil of Washington, D. C., sent me the *x*-ray and tissues from a case similar to that of Dr. Roche in the gross and microscopic appearance, and the *x*-rays in this case give a picture very similar to the lesion in the shaft of the humerus, just described.

Pathol. No. 24096. Figs. 32, 33. Lanahan, patient of Dr. Neil.

This patient is a white female aged twenty-four. She has observed a swelling in the mid-shaft of the tibia for sixteen years (since age of eight years). There is no history of trauma or fracture. On account of recent pain, (six months) she sought advice. The *x*-rays (Figs. 32 and 33) show a definite marrow shadow with slight expansion. The sharp outline of the shadow in the lateral view and the longitudinal dark lines in the antero-posterior view suggest,

in my opinion, a healing process undergoing ossification. This was later proved by the presence of new bone in many islands in the solid mass of ostitis fibrosa. This patient is well now one year after curetting, and the cavity is almost filled with new bone.

In this case as well as in the one of Dr. Roche, we have examples of bone cysts or ostitis fibrosa which have failed to heal spontaneously, even after periods of five and sixteen years. In these two cases the long duration of the tumor, I think, excludes a central sarcoma.

Pathol. No. 25542. Fig. 34. This is a recent observation of Dr. Baer of Baltimore, *x*-ray by Dr. Baetjer, in which the diagnosis of ostitis fibrosa was made on the clinical history and *x*-ray picture.

The patient is a white female aged seventeen. Swelling and bending of the shaft of the tibia had been present twelve years (since five years of age). There is no note on trauma, and there is no pathological fracture. Fig. 34 shows the *x*-ray. One can see in the *x*-ray evidence of ossification, similar to that in Dr. Neil's case, and this was confirmed by the microscope. Dr. Baer performed a subperiosteal resection.

In 1912 Dr. Mixter of Boston sent me a solid piece of tissue removed from the center of the crest of the iliac bone.

Pathol. No. 12378. The patient was a white female aged nineteen. Pain had been present six and one-half months; swelling two and one-half months. I did not see the *x*-ray. Dr. Mixter removed the lesion locally and reports in 1920, eight years since the operation, that there has been no recurrence. The gross specimen in this case closely resembles that in Pathol. No. 25656, in the presence of minute cysts and red currant-jelly areas.

Histology of Ostitis Fibrosa. If the bone cyst is not lined by connective tissue, one finds the picture of ostitis fibrosa in the dilated Haversian canals of the bone shell. If the bony shell of the cyst has a connective tissue lining, or is filled with a solid mass of this fibrous tissue, the histology

is practically identical with that in the dilated Haversian canals of the bony shell.

In the *Annals of Surgery* for August, 1910, Fig. 23 illustrates the picture in the bony shell, Fig. 22 the bone shell and connective-tissue linings, Figs. 20 and 21 areas containing giant cells which usually in the gross appear as red currant-jelly areas, and Fig. 19 islands of cartilage which is a rather rare finding and, if not carefully studied may be mistaken for myxomatous areas.

In nearly fifty cases of bone cysts with ostitis fibrosa which I have studied histologically, I have never found an area of pure myxoma.

But in almost all of them, as in Pathol. No. 25656, one may find very cellular areas either of spindle cells, or of round cells. The spindle cells are apparently of the connective-tissue type which ultimately form fibroblasts and fibrous tissue, and the round cells are either osteoblasts which have not yet formed bone, or proliferation of the endothelial cells of blood vessels. In a number of these cases, where the tissue has been sent to the laboratory for diagnosis, a diagnosis of sarcoma had been made from the frozen section. But in only one did the operating surgeon act upon this diagnosis and amputate.

I have carefully compared the sections of ostitis fibrosa with all my cases of periosteal and central sarcoma, and find no histological picture in the sarcoma which resembles the cellular area in ostitis fibrosa, and when these sections have been submitted to the special groups of third-year students, they have almost uniformly been able to differentiate the sarcoma from ostitis fibrosa from a study of the sections only.

Age of Onset Fifteen to Twenty Years. At this period of life the age of onset becomes less significant.

Cysts	12 cases
Central sarcoma	5 cases
Myxoma and chondroma	No cases

Among the five cases of central sarcoma there is one

which shows that the *x*-ray will not differentiate between the cyst, the giant-cell tumor and the central sarcoma, and for this reason at this age immediate exploration is indicated.

Pathol. No. 7964. Fig. 3. The *x*-ray and tissue in this case were sent to me by Dr. Ernest Codman of Boston. The patient was a white male aged seventeen. There had been a history of trauma three months before followed by pain and rapid swelling of the upper end of the fibula. The *x*-ray (a poor one) (Fig. 3) taken three months after the onset apparently shows a central tumor in the upper end of the fibula with the preservation of the bony shell. This *x*-ray is somewhat like the two I have reported (*Annals of Surgery* for August, 1912, Figs. 7 and 8, of a patient of Dr. Chambers of Baltimore, and Figs. 24 and 26, my own case). These two cases were giant-cell sarcomas. In my case (Pathol. No. 11855) I resected, and the patient is well (1920) nine years. Chambers, Fig. 4 (Pathol. No. 12926v), first curetted and later resected for a recurrence, and this patient, too, is well six years since the operation for recurrence and eight years since the curetting.

Codman's case (Fig. 3) should be always borne in mind —as a definite demonstration that the *x*-ray in the early stage of central sarcoma cannot be depended upon to differentiate the benign from the malignant lesion.

This patient of Dr. Codman refused operation when this *x*-ray was taken three months after onset. Six months later, nine months after the onset, the *x*-ray showed that the bony shell had been completely destroyed, but this *x*-ray finding does not exclude a giant-cell tumor (see my report in *Annals of Surgery,* April, 1919, Figs. 2 and 4). Dr. Codman amputated. The patient died one year later from metastasis to the lung. The tumor is a large round-cell sarcoma containing a few giant cells of the giant-cell tumor type.

The *x*-rays of this case (Pathol. No. 7964, Fig. 3) are reproduced from prints and are so poor that the diagnosis of central sarcoma may be questioned.

Treatment of Central Tumors of the Upper End of the Fibula. The case which I reported in *Annals of Surgery* for August, 1912, Pathol. No. 11855, Figs. 24, 25, and 26, demonstrates that one may resect the upper end of the fibula giving the bony shell a margin of soft parts without any interference with the future function of the limb, providing the external cutaneous nerve is not cut. But this produces only a very slight loss of function. It was accidentally cut in my case, but my patient is able to walk and dance, and there is very little loss of function. The same is true in Dr. Chambers' case.

For this reason it is my opinion that resection should be the operation of choice when the *x*-ray shows a central lesion of the upper end of the fibula, whether the bony shell is destroyed or not.

I have also advocated this for central tumors of the lower end of the ulna (see my report on three cases of giant-cell tumor in *Annals of Surgery,* April, 1919).

Age of Onset Over Twenty. Every type of the central bone tumor has been observed between the ages of twenty and seventy. Bone cysts are very rare after twenty years of age (5 cases). The age at which the giant-cell tumor predominates is between twenty and thirty, but eight cases have been recorded between thirty and fifty and two cases between fifty and seventy.

*Bone Cysts with Onset at Over Twenty Years of Age.**

Pathol. No. 5807. Cyst in the trochanter of the femur in a white male aged seventy. There had been a history of contusion two years; pain localized to the trochanter remained; there was some slight swelling of the trochanter. The *x*-ray made in 1904 is not very clear, but it shows a shadow in the trochanter with a rather thick bony shell and no periosteal bone formation. It was explored and curetted by Dr. Halsted in 1904. The cavity contained clear serum. There was no connective-tissue lining. The cavity was situated in the cancellous bone which was rather eburnated. The sections show no evidence of ostitis fibrosa. It is diffi-

*The relation if any of the juvenile and adult bone cyst with each other and with the giant-cell tumor and the malignant bone cyst is not yet determined (July 10, 1920).

cult to classify this cyst. It may have been due to a hematoma following injury. The patient was followed for one year and then lost track of.

Central tumors confined to the trochanter are rare. Dr. Prince of Rochester, N. Y., has sent me one *x*-ray of a bone cyst involving the great trochanter of the femur.

Pathol. No. 17871. *X*-ray (Fig. 2). The patient was a white female aged twenty-three. There has been localized pain for six years; pathological fracture after a slight trauma ten weeks. There has also been a slight intermittent limp for six years. Curetting was done in 1915 by Dr. Prince and there has been no recurrence in five years.

Pathol. No. 5533. This is an example of the rare type of bone cyst because of its huge size due to failure to heal. I have reported this case in *Annals of Surgery* for August, 1910 (Figs. 9 to 12). When the patient first came under observation in Johns Hopkins Hospital she gave her age as thirty-two. She was a colored woman, and the swelling which then involved the lower end of the femur and was as large as a child's head, had been present five years. So that she was twenty-seven years of age at the onset. In view of the huge size of the tumor and the inaccuracy of colored women as to their true age, it is quite possible that the condition had been present longer. At this time (1898), a clinical diagnosis of sarcoma was made and amputation advised, but refused. The patient came under observation again in 1904, six years later. The tumor had increased in size, and I was able to examine the specimen after amputation. It was a multilocular cyst involving both shaft and epiphysis with undoubted evidence of unsuccessful attempt at ossification.

The huge bone cysts of this type are rare—six out of fifty-six cases.

Pathol. No. 20646. Fig. 13. This is also an example of a huge bone cyst of the lower end of the femur. The *x*-ray (Fig. 13) and the data were sent me by Dr. Goodwin of the University of Virginia. The patient was a colored male

aged thirty-five; the swelling had been present for five years, since the age of thirty; two years later there was a fracture, probably pathological, which healed. Increase in size and pain for one month brought the patient to the surgical clinic. A clinical and *x*-ray diagnosis of sarcoma was made and a hip-joint amputation performed in 1914. The patient is well in 1920, six years since operation.

Pathol. No. 8324. This is another example of a large bone cyst with unsuccessful attempt at ossification, and has been completely reported by me in *Annals of Surgery* for August, 1910 (Figs. 16 and 17). The case is mentioned here, because the patient was a white female aged twenty-one when first observed in 1899; she then complained of pain and swelling of six months' duration. At that time a clinical diagnosis of sarcoma was made, amputation advised but refused. She came under the observation of another surgeon ten years later with a huge tumor, when the leg was amputated and the specimen sent to me. I am rather inclined to the view that an *x*-ray in 1899 might have led to a more correct diagnosis, and the limb saved by the proper operative procedure then.

Pathol. No. 20296. Case of Dr. Roche of solid ostitis fibrosa already discussed (page 163). This is mentioned here, because the patient claimed to be twenty-one years of age at the onset of the swelling.

Therefore, of the five cases of bone cysts the onset of which dates from a period after the age of twenty, that is, after the ossification of the epiphyses, the one in the great trochanter (age 70) apparently belongs to a different type; of the four remaining cases three are examples of huge bone cysts, the failure of which to heal spontaneously suggests, perhaps, a different type. There is, therefore, only one case of undoubted bone cyst with ostitis fibrosa, and in this case the age of onset was twenty-one, and as the patient was a female who claimed to be twenty-six at the time of observation, it is quite possible that the disease had been present longer.

Conclusions as to the Age of Onset. Up to the age of fifteen the probabilities favor the benign cyst, with a possibility of now and then a giant-cell tumor. Between fifteen and twenty cysts still predominate, but the central sarcoma must be considered. After twenty, cysts are very rare. The predominant tumors are the giant-cell tumor and the central sarcoma with a few myxomas and chondromas, all scattered up to the age of twenty. Between twenty and thirty the giant-cell tumor predominates.

Duration of Symptoms

If it is more than two years since the symptom of onset, pain, swelling, pathological fracture, or even a history of fracture, the probabilities are that the lesion is a cyst or a giant-cell tumor. Of twenty-three central sarcomas sixteen —more than one-half—came under observation within two years of the onset of the first symptom.

Central Sarcoma with Duration of Symptoms of Two Years or More. Seven out of twenty-three cases.

Pathol. No. 6426. Malignant hemorrhagic bone cyst of lower end of tibia; has suffered pain and swelling in the region of the ankle for twenty-five years; this had been diagnosed arthritis. The swelling had been intermittent. There had been a recurrence of the pain and swelling six weeks before the *x*-ray and operation. (Reported in *Annals of Surgery* for August, 1910, Fig. 39.)

Pathol. No. 24746. Fibrospindle-cell sarcoma of lower end of femur involving the condyles. Swelling for ten and one-half years after trauma. Recent pathological fracture; bony shell thin but preserved.

Pathol. No. 14229. Figs. 20, 21. Malignant hemorrhagic bone cyst of lower end of femur involving both condyles. Pain ten years; flexion two years. Treated for arthritis.

Pathol. No. 13350. Central sarcoma of lower end of humerus. Fracture nine years, swelling since; second trauma one year; rapid swelling six months. Bony shell thin, in

places destroyed with perforation and formation of a periosteal growth.

Pathol. No. 15327. Central myxosarcoma of upper end of humerus. Pain and swelling four and one-half years after trauma. Huge cystic tumor. Bone capsule and head of humerus destroyed.

Pathol. No. 2881. Malignant hemorrhagic cyst of upper end of humerus. Persistent local pain four years, swelling four months. Huge tumor. Bony shell destroyed. (Reported in *Annals of Surgery* for August, 1910, Figs. 40 and 41.)

Pathol. No. 10602. Fig. 26. Malignant hemorrhagic cyst of shaft of humerus. Pain after contusion two years. Pathological fracture five months. Bony shell preserved.

If routine *x*-ray examinations had been made after trauma, fracture, localized pain, or slight swelling, all of these cases would have been recognized earlier.

Among these seven cases one is living today (Pathol. No. 14229), Figs. 20, 21, seven years after amputation of the femur. One patient, a recent case, is still living (Pathol. No. 24746).

Onset Less Than One Month. In spite of the fact that we have had the *x*-rays for more than twenty-five years, and certainly for the past ten or fifteen years, and *x*-ray laboratories have been established all over the country, we have not yet succeeded in educating the profession and the public to the importance of the diagnostic value of *x*-rays after a trauma and the moment a patient experiences localized pain in a bone or joint, or a slight swelling.

Among these 140 patients with central bone lesions only eighteen came for examination within one month.

Of these sixteen were bone cysts; ten of these had fracture, and six marked pain and swelling after injury. This undoubtedly explains why they came under observation earlier.

One patient—a surgeon—(Pathol. No. 20115) sprained his knee in July, 1916. X-rays were taken at intervals until

about August tenth, when the lesion was found in the outer condyle of the lower end of the femur and operation performed September ninth. (See Figs. 11 and 12.) (Previously reported in Transactions Medical Association of State of Alabama, April, 1919, Figs. 20 and 21.)

A case of central chondroma (Pathol. No. 25254) in which the lesion was situated in the phalanx of the toe was *x*-rayed and operated on within two weeks after a pathological fracture.

Only seven out of twenty-three cases of central sarcoma were subjected to operation within six months after the onset of the first symptom. This observation gives hope that if these central sarcomas are recognized and treated within a few days or weeks after the onset of the first symptom, the probabilities of a cure will be greatly increased. Up to the present time we have had but one such opportunity (Pathol. No. 20115) (Fig. 11), and this patient is well now three and one-half years since operation. We have already recorded the percentage of cures in all cases as less than ten per cent.

Duration of Bone Cysts. The longest duration of a bone cyst is about twelve years, but in eleven cases the duration was more than five years. I will discuss this again later under Healing of Bone Cysts.

Duration of Giant-cell Tumors. The longest is nine years; in three cases over five years; in eight two to three years. There is apparently no relation between the duration of the symptoms and the preservation of the bony capsule.

Duration of Chondroma and Myxoma. Both of these may give the history of long duration with preservation of the bony shell.

Relation Between Duration of Symptoms and Local Growth. Apparently the central sarcomas grow less rapidly than the periosteal, but with bone tumors as with neoplasms in general, the duration of the symptoms does not by any means correspond with the size or infiltration of the growth. Many other factors apparently influence this

growth as repeated trauma due to either definite injury, or to the position of the bone lesion.

Symptoms of Onset. In all bone tumors, except the bone cyst, the predominant symptom of onset is localized pain, while in the cyst it is swelling or pathological fracture. Pain is frequently absent in the bone cyst. Pain has never been absent in the giant-cell tumor, nor in the malignant hemorrhagic cyst. In a few cases it has been absent in the central sarcoma.

As I have emphasized before, localized pain in a bone or joint should be looked upon as a more emphatic indication for an immediate *x*-ray examination than fracture. We have educated the public and the profession to the routine examination with the *x*-rays after fracture, but not for pain nor slight swelling, nor interference with function, such as a limp.

Symptom of Onset with Arthritis. In only two cases did the symptoms at the beginning or later suggest arthritis. They were both malignant cysts, one in the lower end of the femur, and the other in the lower end of the tibia. This is unusual, because the majority of central bone tumors, except the bone cyst, involve the lower end of the bone and the epiphysis. In periosteal sarcoma situated near the joint, joint symptoms are more apt to be present, but the bone lesion which most prominently is associated with symptoms of arthritis is tuberculosis of the epiphysis.

Limp. This has been the symptom of onset or a later symptom when the tumor has involved one of the bones of the lower extremity. But limp or loss of function has rarely been the symptom of onset in central sarcoma. It is definitely recorded in but one case.

Onset Pain with a Definite Interval Before the Appearance of Any Other Symptom. This is a very important observation and confirms the statement already made of the importance of an *x*-ray examination for localized pain in a bone or joint.

In ten out of twenty-three central sarcomas, pain pre-

ceded any other definite symptom from periods of four months to almost four years. In giant-cell tumors, in ten out of forty-eight cases pain was present for some time—months or years—before the appearance of the swelling.

In bone cysts this is less frequent.

Fracture. This is the predominant feature in bone cysts. Out of some fifty cases in which we have full data, there is a history of fracture in fourteen; the fracture healed, and the patient came later under observation with swelling or pathological fracture. In fourteen cases pathological fracture was apparently the first symptom; in three cases the pathological fracture occurred later. The total number of fractures is twenty-seven, that is, in more than fifty per cent. of the cases.

In the giant-cell tumor there was fracture in but five out of about fifty cases, or in ten per cent; four patients gave a history of a fracture which had healed. So we cannot tell whether it was pathological or not. In not a single case was pathological fracture the symptom of onset. In one case it was observed later.

It is not difficult to understand why fracture is more frequent in cysts than in the giant-cell tumor. It is because the cyst usually involves the shaft of the bone, and fracture has been observed chiefly when the cyst is in the shaft of the humerus or of the femur, while the giant-cell tumor as a rule involves the epiphysis, lower end of radius, upper end of tibia, and lower end of femur.

In the central sarcoma there is not a single case of pathological fracture as the symptom of onset. In the twenty-three cases in which we have definite records fracture is noted in but six, about twenty-five per cent.—one-half as frequently as in the cysts, but more frequently than in the giant-cell tumor. In two cases there is a history of fracture which had apparently healed: one nine years, one two years before. There are four pathological fractures. It is difficult to explain the infrequency of pathological fracture in central sarcoma, except that these patients may have more

pain and therefore do not expose themselves to the possibility of trauma.

The Significance of Pathological Fracture as the Symptom of Onset. This evidence indicates that fracture as the symptom of onset in a central lesion suggests a bone cyst, and if the patient is fifteen years of age or younger, it may be looked upon as almost pathognomonic. (See Pathol. No. 25656, Fig. 89, bone cyst of the shaft of the humerus, discussed on page 160.)

X-ray Picture of Central Bone Lesion. While I have numerous *x*-rays of cysts, the giant-cell tumor, chondromas and myxomas, and the hemorrhagic cystic sarcoma (bone aneurism), I have very few of the central solid sarcomas. This is due to the fact that in recent years cases of this type have not come under my observation. I have one *x*-ray of a myxosarcoma in the greater tuberosity of the humerus (Fig. 1) (Pathol. No. 19133-VII), and this differs little from Fig. 2 (Path. No. 17871-iii), a bone cyst in the trochanter of the femur. But on closer inspection one sees in the *x*-ray of the myxosarcoma of the tuberosity of the humerus a hazy dark shadow of new bone formation, or calcification of tumor tissue between the humerus and the scapula. This reaction of the periosteum with bone formation is never present in the cyst, the giant-cell tumor, the myxoma or the chondroma, and it is rare in central sarcoma, where tumor cells have infiltrated through the Haversian system into the soft parts, irritated the osteoblasts of the periosteum and stimulated bone formation. The study of the gross specimen in Fig. 1 demonstrated this, and the failure of the roentgenologist and surgeon to observe it in the *x*-ray led to a local resection and bone transplantation instead of local resection of the humerus and a piece of the scapula with the cautery, or a shoulder-girdle amputation. Later this patient came under my observation with local recurrence, but died of lung metastasis without local recurrence after the shoulder-girdle amputation which I performed.

Of eleven cases of solid cellular sarcoma I have *x*-rays of but three. One has already been discussed (Fig. 3) (Pathol. No. 7964-x). Here the *x*-ray three months after onset showed a central(?) tumor in the upper end of the tibia with preservation of the bony shell(?) impossible to differentiate from the *x*-rays of three cases of central giant-cell tumor of the upper end of the fibula (Fig. 4).

I have already noted that I now look upon this picture (Fig. 3, Pathol. No. 7964) as too poor for any definite conclusions.

Central Tumors of Upper End of Tibia. I have records and *x*-rays of seven benign cysts, six giant-cell tumors, and three central sarcomas; there is an *x*-ray of but one sarcoma.

Fig. 5 (Pathol. No. 16297-iii) proved, at operation, to be a bone cyst lined by a rather thick connective-tissue membrane. Fig. 6 (Pathol. No. 12276-v) proved to be a giant-cell tumor. The most striking difference is the involvement of the epiphysis in the giant-cell tumor, and the complete preservation of the epiphyseal line in the bone cyst, although on the fibular side it extends to the epiphyseal line. The apparent destruction of the bony shell in the giant-cell tumor on the fibular side is not diagnostic from a bone cyst, although on the whole it is more frequent in the giant-cell tumor. The division of the central shadow by irregular dark lines supposed to be characteristic of the giant-cell tumor, especially emphasized by some authorities some years ago, is seen here in both the cyst and the giant-cell tumor.

The clinical history of the bone cyst was (Fig. 5): White female, aged thirteen; contusion seven months ago; swelling with expansion of tibia six months; no pain, but slight tenderness. I curetted this cyst in 1915, and the patient is well in 1920, five years.

It is interesting to note here that pathological fracture has never been observed in central tumors in this portion of the tibia.

The giant-cell tumor shown in Fig. 6 was in a white male aged twenty-two; there had been pain for one year, swelling for ten months. This patient is well six years after resection with bone transplantation.

Fig. 7 (Pathol. No. 13092-x) central sarcoma of upper end of tibia diagnosed first osteomyelitis, is the only *x*-ray I have of an early central sarcoma. It will be observed that the shadow does not resemble that of a cyst or giant-cell tumor, nor that of a malignant bone cyst, but shows indefinite, irregular light areas in the upper end of the tibia involving the epiphysis with little, or no, expansion of the cortical bone and no evidence of periosteal bone formation, except at one point posterior, above the fibula. This *x*-ray picture is not unlike early osteomyelitis.

The clinical history in the case was against a bone cyst and against osteomyelitis. The patient was a white male aged thirty-nine, distinctly beyond the age for the cyst. There is the history of a trauma two years ago; the pain, tenderness and swelling after this trauma subsided, and then, one year before operation, without a second trauma, the pain and swelling returned. There was no fever or leucocytosis usually present in osteomyelitis; even in chronic osteomyelitis with pus the leucocytes show a change. There was no involvement of the soft parts which as a rule takes place within one year in osteomyelitis. Perhaps in the chronic osteomyelitis with formation of an abscess, as first described by Brody, there may be no involvement of the soft parts. But here there is sufficient destruction of the marrow to produce a central shadow. This type of osteomyelitis is rare. I have never seen an *x*-ray of such a case. Many years ago, before the advent of the *x*-rays, I operated on two cases. Both, however, showed new periosteal bone formation in the thick bony shell surrounding the abscess. In this case (Fig. 7) the head of the tibia was curetted on the diagnosis of osteomyelitis, and one month later, when a fungous tumor formed in the wound, the leg was amputated, and the patient died later with metastasis to the lungs. Un-

fortunately I can obtain no accurate description of the gross picture at the first operation. But this *x*-ray suggests that central sarcomas may give this unusual picture, demonstrating the importance of the point made in the beginning of this paper, that the pathology must be settled at the exploratory incision.

Fig. 8 (Pathol. No. 3931-x) is the photograph of a longitudinal section through what is apparently a central sarcoma of the upper end of the tibia.

Of eleven cases of central sarcoma I have already called attention to one in the upper end of the fibula in which the bone capsule was preserved and which resembled three other cases of central giant-cell tumor of the upper end of the fibula (Fig. 3), and then to one in the upper end of the tibia which had not broken through the bony shell, but had produced a mottled shadow in the upper end of the tibia (Fig. 7). And then to one (Fig. 52) involving the upper end of the radius with complete destruction of the bone. *The remaining eight cases in their gross pathology resembled the one illustrated in Fig. 8 (Pathol. No. 3931), in that there is little or no expansion of the bony shell about the central sarcoma, but a rapid perforation with prompt destruction of the bone shell and then formation of some periosteal bone with, later, a definite periosteal tumor.*

When we have a picture of this kind it is difficult to determine whether the tumor is a primary central or periosteal growth, but for the practical purposes of diagnosis and treatment this makes no difference.

Therefore, from my personal experience central sarcoma of bone is a rare lesion, and in practically all cases in which the bony shell has been preserved, the tumor has been of the type of the malignant hemorrhagic bone cyst (bone aneurism).

Central Tumors of the Lower End of the Femur. Fortunately I have two cases—one a giant-cell tumor, the other a malignant hemorrhagic bone cyst, involving the condyle of the femur. Figs. 9 and 10 (Pathologic No. 9881-v) picture

the *x*-ray and specimen of the giant-cell tumor, and Figs. 11 and 12 (Pathol. No. 20115-xiii) the *x*-ray and gross pathology of the malignant bone cyst. The bony capsule is preserved about the giant-cell tumor, while it is destroyed on the outer side about the sarcoma. In my entire experience I have never observed in a giant-cell tumor as small as this sarcoma, a destruction of the bony shell. Then, again, the light area of the giant-cell tumor is more sharply demarkated from the cancellous bone of the uninvolved femur, than the sarcoma. Figs. 9 and 10 (Pathol. No. 9881) have been previously reported by me in *Annals of Surgery* for August, 1910. I operated on this patient with Dr. DaCosta in Philadelphia in June, 1909, resecting the involved area. The patient is well (1920) eleven years.

The sarcoma (Figs. 11 and 12) was subjected by me to amputation of the femur in September, 1916, and this patient is well (1920) three and one-half years.

In the lower end of the femur I have for study 1 chondroma, 9 benign bone cysts, 11 giant-cell tumors, 2 fibrosarcomas, 6 central sarcomas, and 4 malignant bone cysts. This gives one a large opportunity to make a differential study of the *x*-ray pictures, but does not lead to a conclusion that any of these lesions have a characteristic *x*-ray appearance, at least in the stages in which they come under observation.

Benign Bone Cysts. Fig. 13 (Pathol. No. 20646-iii) is the *x*-ray sent me by Dr. Goodwin of the University of Virginia, and is an example of the so-called large bone cyst which has already been described (page 168). The bony capsule is practically preserved; the condyles are replaced by the shadow of the tumor; the bony capsule of the tumor rises abruptly from the shaft of the femur; there is no new periosteal bone formation at the junction of the tumor and uninvolved shaft; the tumor shadow is irregularly marked with dark lines giving it a distinctly mottled appearance. When we compare it with the large bone cyst reported in the *Annals of Surgery* for August, 1910 (Figs. 10 and 17), it is an entirely different picture: in all three the bony shell

is preserved, but in the other two the shadow was not marked by the irregular dark lines, that is, not mottled.

On the whole the *x*-ray resembles Fig. 14, Pathol. No. 20209-iii, a large bone cyst of the shaft of the femur of a patient of Dr. Prince of Rochester, N. Y. But in this case the shadow of the shaft of the femur is preserved to a large extent, while it is lost in Dr. Goodwin's case.

Central Chondroma. Fig. 15 (Pathol. No. 22016-ii) shows the preservation of the bony shell, but very little, if any, expansion of the lower end of the femur. It shows the mottling from the dark lines which is more common in the giant-cell tumor than in the cyst. This patient was a white female aged fifty-one, and had pain and limp for seven years. But as there was pain in other joints, she came under observation with the diagnosis of multiple arthritis, and this *x*-ray was found accidentally in the routine examination. The nature of the tumor was not determined until the exploratory operation. The gross appearance of the tissue beneath the bony capsule was typical of cartilage, as confirmed by the frozen section. This patient has remained well now (1920) almost four years after curetting and radium treatment. The function is good. I have no better example in my group of cases to demonstrate the difficulty of a correct diagnosis from the *x*-ray only. The clinical picture in this case was against a giant-cell tumor, against a central sarcoma, because all our central sarcomas reaching such size have had much more pain; then, again, the long duration of the slight symptoms—limp and slight pain —without expansion or perforation of the bony shell favored the diagnosis of a chondroma or myxoma.

Giant-Cell Tumors. Figs. 16 and 17 (Pathol. No. 25778-v) show the antero-posterior and the lateral view of a central tumor of the lower end of the femur. This is a recent case and has not yet been operated on. The age of the patient is that in which the giant-cell tumor most commonly occurs. It is of short duration—less than one year, which practically excludes a large bone cyst. The pain is very much less

than in a central sarcoma in this region. The expansion has been more rapid than in any central chondroma or myxoma under my observation. The epiphysis is involved. It shows the mottling of the giant-cell tumor. The picture closely resembles Pathol. No. 10975, reported by me in *Annals of Surgery* for 1912, Fig. 18, a giant-cell tumor of the upper end of the tibia, except that the expansion is not so marked.

Central Fibrosarcoma. Figs. 18 and 19 (Pathol. No. 23407-viii) show the *x*-ray and gross specimen. In the *x*-ray the bony capsule on the outer side is destroyed; on the inner side with part of the internal condyle, it is preserved. The preserved shaft of the femur above shows teeth-like projections of bone into the tumor. There is no periosteal bone formation. The shadow of the tumor is not mottled, although it is not smooth. When we look at the picture of the gross specimen, we see that the bone defect is filled with a solid tumor not unlike a fibroma.

Tumors of this kind are common in the lower jaw and have been removed by local resection. This patient was a white female aged twenty-nine; there was a history of contusion ten months ago, but no swelling until four months ago; there was practically no pain and no limp. If this history is correct the tumor must have grown rapidly and apparently by pressure destroyed the outer bony shell. In this case the leg was amputated without exploration, and the patient is well (1920) two years since operation. Microscopically, the tumor belongs to the group usually called fibrospindle-cell fibrosarcoma. In this type situated in the soft parts and in the lower jaw, I have never observed death from metastasis and no recurrence when the local growth was properly removed. In my opinion, in this case exploration should have been done, and when the character of the tumor had been determined, local removal with the cautery and bone transplantation would have given the patient as large an assurance of a cure and a limb with good function. This type of tumor is rare. Gross and microscopically it closely resembles solid ostitis fibrosa.

Central Sarcoma. Malignant Bone Cyst Type. (Bone Aneurism.) In the *Annals of Surgery* for August, 1910, I reported three cases: one in the lower end of the tibia (Pathol. No. 6326), one in the upper end of the humerus (Pathol. No. 2881), and one in the lower end of the femur (Pathol. No. 8951), at that time giving the literature. In the *Annals of Surgery* for April, 1919, I again referred to this subject. I now have records of five additional cases, making a total of eight cases: one in the shaft of the humerus (Pathol. No. 10602) (Fig. 26; pages 151 and 171); three in the lower end of the femur (Pathol. No. 14229, Figs. 20 and 21; pages 152, 154; Pathol. No. 19179, Figs. 23, 24, and 25; page 182; Pathol. No. 20115, Figs. 11 and 12; pages 172 and 179), and one in the shaft of the tibia (Pathol. No. 15404½).

It is interesting to note that among these eight cases four were in the lower end of the femur. In six cases the bony shell or a connective-tissue capsule confined the tumor; in two cases there was rupture with the formation of a hematoma outside the capsule or bony shell. One patient lived nine years and died of metastasis to the lung; one lived four years and died of metastasis to the lung; three are living today: one six years and other two, three and one-half years after amputation.

This central malignant bone cyst must be distinguished from the central giant-cell tumor containing blood. I have carefully discussed this from a differential-diagnosis standpoint in *Annals of Surgery* for April, 1919, and in the Transactions of the Medical Association of the State of Alabama, for April, 1919, so that it need not be repeated here.

Pathol. No. 19179-xiii. Malignant bone cyst of the lower end of the femur (Figs. 23, 24 and 25.) The *x*-rays (Figs. 23 and 24) are not strikingly different from the giant-cell tumor in this area (Figs. 16 and 17). The only point to make one suspicious is the pathological fracture which has as yet not been observed in the giant-cell tumor of the lower end of the femur, even when both the condyles and the lower

portion of the shaft were involved. Fig. 25 is a longitudinal section through the femur and the tumor. It shows the cavity, the bony shell posteriorly and the tumor tissue lining the bony shell. The thickness of this tumor tissue has varied in the different cases: in two it was so that the tumor could only be recognized after section. In all of the cases, except this one (Fig. 25), the cavity was filled with blood. In this case the contents of the cyst was clear serum. Clinically, the patient was a white female aged thirty-one; there has been pain and swelling one year, pathological fracture three months. A piece was excised and sent to me for diagnosis. The section shows a spindle-cell sarcoma. I amputated the femur in May, 1916, and the patient is well now (1920) almost four years.

Central Tumors of Lower End of Radius. Of sixteen tumors of the radius fifteen involved the lower epiphysis: thirteen giant-cell tumors and two cysts. The sixteenth case was a central sarcoma involving the upper end of the radius with complete destruction of the bony shell (Pathol. No. 17671, Figs. 52 and 53). I have also observed one case of tuberculosis of the lower end of the radius giving an *x*-ray picture like a cyst or giant-cell tumor (Fig. 37) and one in the center of the shaft of the radius which was diagnosed central sarcoma and treated with radium until the bone shell perforated and an extraosseous abscess developed.

In this case where the *x*-ray showed a central shadow in the shaft of the radius with preservation of the bony shell, the patient was an adult over thirty years of age, and it brings up perhaps the most debated question in treatment.

Some authorities are of the opinion that there is no harm to try *x*-rays or radium first, because, if the central tumor were benign, no harm would be done; if malignant, radium acts better without disturbing the neoplasm by the trauma of operation.

My personal opinion in regard to a case of this kind is this: The *x*-ray showing such a definite bone shell indicates

that the lesion could be completely resected with bone transplantation and perfect preservation of function. This is the most certain cure. For this reason, as the age practically excludes a bone cyst, I would explore to demonstrate whether the central lesion is tuberculosis, a giant-cell tumor, a myxoma, chondroma, or the rare central sarcoma. If it proved to be sarcoma, myxoma or chondroma, I would resect after destroying possible residues of tumor cells, a method to be described later under Exploratory Incision.

In this case the radium treatment first was associated with perforation and involvement of the muscle with tuberculosis, and this patient has an arm with very restricted function, while immediate exploration would have led to a correct diagnosis and resultant perfect function.

There are without doubt lesions in which radium and *x*-ray treatment should be tried first. The method of treatment varies with the bone involved, the portion of the bone involved, whether the tumor is central or periosteal, with the age of onset, duration of the tumor, the presence of a pathological fracture and our accumulated knowledge of the possible different pathological processes in the portion of bone involved. No general rule can as yet be laid down.

Fig. 36 (Pathol. No. 21191) is an *x*-ray of a bone cyst. Fig. 37 (Pathol. No. 23552) shows tuberculosis. Fig. 38 (Pathol. No. 23895), tuberculosis of the lower end of the tibia, is shown here for comparison. Fig. 39 (Pathol. No. 12927) shows a giant-cell tumor.

These cases demonstrate the difficulties of a differential diagnosis from the *x*-ray only.

Pathol. No. 21191-iii (Fig. 36), benign cyst of lower end of radius, was a white male aged twenty-six. There had been pain and swelling in the lower end of the radius for ten years; recently the pain and swelling had increased after a slight trauma. In 1917 this patient with the *x*-ray were demonstrated before a surgical society in Washington, D. C. The majority favored the diagnosis of a cyst or giant-cell tumor, a few central sarcoma. I explored the

lesion under novocaine, found a thin bony shell, a cyst lined by thin connective-tissue membrane filled with fluid. The connective-tissue lining was removed and the wound closed. The patient is well (1920) three years.

Fig. 37 (Pathol. No. 23552), tuberculosis of lower end of the radius and shaft of phalanx of index finger with involvement of the joint. This case in the *x*-ray was diagnosed a cyst.

The clinical picture as well as the *x*-ray suggested tuberculosis. It is true that cysts may be multiple, but they rarely involve a joint. This patient was a white female, aged 22, with a history and evidence of tuberculosis of lungs. Swelling of the wrist followed an injury nine months ago. The swelling was incised and pus evacuated. A sinus persisted. Four months ago, excision of piece of tissue from sinus was diagnosed sarcoma. The *x*-ray, Fig. 37, shows a shadow in the lower end of radius not unlike a bone cyst, (see Fig. 36). But the *x*-ray of the phalanx and joint of the index finger suggests tuberculosis, which was confirmed by the microscopic study of the tissue removed.

Fig. 38 (Pathol. No. 23895) is an *x*-ray of a lesion of the internal maleolus. It shows both bone destruction and bone formation. The tissues sent to me from this lesion show tuberculosis. It was diagnosed syphilis because of a Wassermann plus reaction. This *x*-ray should be compared with Fig. 37 and Fig. 59.

Fig. 39 (Pathol. No. 12927), a patient of Dr. Emil G. Beck of New York, proved to be a giant cell tumor of the lower end of the radius. It is a very early case and has distinct mottling of the central shadow in contrast to Fig. 36, a bone cyst.

Fig. 40 (Pathol. No. 16720), a giant cell tumor of lower end of radius with a preservation of the bone shell in spite of extreme expansion. It should be compared with Fig. 39, an earlier stage of this giant cell tumor, and Fig. 41 (Pathol. No. 2420), a giant cell tumor of the lower end of radius which has completely destroyed the bone shell.

Destruction or perforation of the bony shell in central bone lesions is not necessarily a sign of malignancy. I consider this point in great detail in my report to the *Annals of Surgery,* April, 1919, in relation to the central giant-cell tumor. In the Transactions of the Medical Association of the State of Alabama, April, 1919, I called attention to the fact that this perforation and partial destruction of the bony shell may take place in a bone cyst (see especially Fig. 3, Pathol. No. 21580). I emphasize this again because within the past few days one of our most experienced roentgenologists in interpreting an *x*-ray of a central lesion of the first phalanx of the little finger diagnosed sarcoma, because the bony shell was perforated at one point. The tumor proved to be a benign chondroma and could have been removed by local resection.

Figs. 42 and 43 are photographs of the forearm and the gross specimen of the *x*-ray shown in Fig. 41.

In this case, in spite of the local infiltration of the giant-cell tumor, the patient is free from recurrence more than 20 years after amputation.

Fig. 44 (Pathol. No. 1815) and Fig. 45 (Pathol. No. 6125) are photographs of the gross appearance of the central giant-cell tumor. Amputation was performed in Fig. 44, and resection in Fig. 45. A cure has been accomplished by curetting in a similar case by Dr. Chambers of Baltimore (see *Annals of Surgery,* August, 1912, Fig. 13).

Exploratory Incision. In view of this description of central lesions of bone and what we will describe later of periosteal lesions, one must conclude, at least for the present, that in a large number of cases a diagnosis cannot be made without an exploratory incision.

The object of this exploration is to establish, if possible, the nature of the lesion.

In making this incision one should employ a technique which has for its object the prevention of infection of the freshly cut normal tissues by tumor cells. This has been described under Myxoma (page 155).

The following case demonstrates how an exploratory incision for diagnosis would have prevented a mutilating amputation of the hand. Fig. 46 (Pathol. No. 24682) is a lateral *x*-ray of the hand, and Fig. 47 an anterior-posterior view. In this case from the clinical picture and the *x*-ray a positive diagnosis of sarcoma destroying the metacarpal bone of the middle finger was made, and the arm amputated without an exploratory incision. The patient was a white, male, age 34, a chauffeur, and had observed the swelling 10 months. The swelling as shown in the *x*-ray was large, it was soft and boggy, with oedematous skin. It was not unlike the case I reported in *Annals of Surgery,* April, 1919, Fig. 1.

If a small incision had been made under novocaine and the tumor exposed, its benign nature would have been recognized and the tumor could have been removed with the cautery, sacrificing only the middle finger and the metacarpal bone, as the lesion proved to be a giant-cell tumor.

The gross pathology is illustrated in Figs. 48 and 49.

Periosteal Bone Lesions

Cases for Study.

Exostoses	110 cases
Periosteal Chondroma	8 cases
Periosteal Myxoma and Chondromyxoma	13 cases
Periosteal Giant-cell Tumors	4 cases
Sarcoma, cellular	68 cases
Periosteal Ossifying Sarcoma	7 cases
Periosteal Myxosarcoma	5 cases

Results in Periosteal Sarcoma. This has already been discussed on page 1. In 52 cases followed there were but 2 cures, less than four per cent.

Contrast of Periosteal and Central Lesions. Attention has already been called to the striking feature of the central bone cysts, giant-cell tumors, chondromas, myxomas, and central sarcomas, especially the malignant hemorrhagic cystic type. Here the central lesion first replaces the mar-

row and cancellous bone, forms a thin bony shell, and then distends this bony shell. In this stage, in the cases studied, even when the bony shell shows considerable expansion, there is no evidence of periosteal bone formation. Attention has also been called to the fact that in a few cases a tubercular osteomyelitis localized in the shaft of long pipe bones, or in the epiphysis (lower end of the radius), we may have the same central shadow with the formation of the bony shell without ossifying periostitis.

In the bone cyst and in the giant-cell tumor the bony shell may be perforated or destroyed without the formation of periosteal bone. So far, in central chondroma* and myxoma, with one exception, destruction of the bony shell has not been observed. In one case, in which the bony shell was partially destroyed (Fig. 30) (Pathol. No. 22929), the myxoma in the tubercle of the tibia, there was no evidence of ossifying periostitis in the *x*-ray or specimen.

From a study of gross specimens apparently the central sarcoma may perforate and destroy the bony shell without producing any bone reaction in the periosteum (Fig. 52).† But this may take place (see Fig. 1 and page 175). The characteristic feature, therefore, of the central bone lesion, whether benign or malignant, is the absence of periosteal bone formation.

Another striking feature of all central bone lesions, with the exception of the healing bone cyst, is the absence of bone formation in the central bone tumor. This has been confirmed by a careful review of *x*-rays, gross specimens and microscopic sections. Bone formation has only been observed in healing ostitis fibrosa, or the bone cyst, and in these cases the ossification of the lesion may be complete, and in many cases the size and architecture of the area of bone involved is restored to normal.

In periosteal lesions the characteristic feature in the

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*I have just called attention to the perforation of the bony shell of a chondroma of the phalanx observed since this was written.

†The same has been observed in periosteal sarcoma. See Fig. 75 and page 201.

great majority of cases is periosteal bone formation and when the tumor tissue invades the shaft, or the underlying bone, especially in sarcoma, bone formation (of the endosteal type) as a rule takes place side by side with the replacement of cancellous bone and marrow tissue by the cells of the invading tumor.

In syphilitic and pyogenic periostitis and osteomyelitis we observe in the *x*-ray and in the specimen, mixed with the granulation tissue, periosteal bone formation of varying degrees. Associated with this there is destruction of the cortical cancellous bone and of the marrow tissue, sometimes with and sometimes without endosteal bone formation. Therefore, syphilitic periostitis and that usually associated with tubercular osteomyelitis and pyogenic osteomyelitis may give *x*-ray pictures difficult to interpret from periosteal sarcoma, and many mistakes have been made.

The exostosis is always a periosteal lesion. As a rule it rests upon a fairly normal bone. The exosteal growth is composed chiefly of cancellous bone. It may show an outer condensed zone of bone, and many are covered with cartilage and a few with a bursa. As a rule the exostosis does not excite much periosteal bone formation about its base. This bone lesion is the easiest to recognize in the *x*-ray.

There is little difference between the periosteal chondroma, chondromyxoma and myxoma. The chondroma and myxoma produce a shadow much lighter than that of normal bone. At the base of this periosteal lesion there is always a collar of periosteal bone formation, and in some cases this collar thins out and is continuous with the bone shell covering the entire exosteal growth. In both, the chondroma and myxoma, but more frequently in the chondroma, trabeculae of bone separate the cartilage or myxomatous tissue and are seen in the *x*-ray. As a rule in the chondroma there is little or no destruction of the cortical bone on which it rests. In the great majority of cases the periosteal chondroma, chondromyxoma and myxoma can be distinguished in the *x*-ray from the true exostosis because

of the lighter shadow. The chondroma may produce very large periosteal growths.

My study, however, demonstrates that when one operates on a periosteal growth which clinically and in the x-ray gives no suggestion of a periosteal sarcoma, the possibility of myxomatous tissue being present in the exosteal growth, should be determined at once (Fig. 56) unless the growth can be excised with a good margin of healthy tissue (Fig. 61) and without exposure of tumor tissue. If such growths contain myxomatous tissue, it is far better for the patient to be left alone, than to be explored without the precautions which I have described.

In every case of periosteal myxoma explored and then apparently completely removed there has been recurrence leading to either amputation or death. (See Fig. 58.)

Exostosis. This is a very conglomerate group, but all periosteal growths composed chiefly of bone have been placed here. There are 110 cases. In 89, as far as the records go, the exostoses were single, in thirteen the os calcis was involved on both sides. In only eight cases was the exostosis a multiple lesion of the skeleton.

Of the 89 single exostoses, as far as could be made out from the history, none were congenital, but this does not prove that they were not of congenital origin. Trauma is stated to have been a definite factor in only thirteen, fracture in five, infected wound in one. As fracture is a pretty definite clinical factor, the probabilities are that this has a small relation to exostosis, and when we consider the absence of a history of trauma and any other definite etiological factor, one gets the impression that many of these exostoses were of congenital origin, and if *x*-rays had been taken of all the bones, other exostoses would have been demonstrated. The records in this group are unfortunately meager. The patients have come under observation, because they have felt the tumor, some with and some without pain, and as the diagnosis was simple, rarely has more than one bone been *x*-rayed. There is opportunity in future

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cases for a much more thorough investigation. In these single tumors practically every bone of the body has at least been involved once. The femur predominates with twenty-one cases; the os calcis next with thirteen, all bilateral; the humerus with fifteen; the tibia and phalanx of the toes with seventeen; the scapula with five; the skull with three; the remaining bones with two or one.

The age of onset varied from under ten to seventy years. In no particular age is there a predominance of the lesion. There is the same variation of the duration of symptoms.

Fig. 54 (Pathol. No. 6367-i) was diagnosed a benign exostosis 1905. It had been observed some six months. Age 30. He wore a belt and had symptoms of syphilis. No operation was performed. It is now fifteen years and the exostosis is no larger. A later *x*-ray showed a small exostosis on the other side. It has not the appearance of a syphilitic periostitis.

Fig. 55 (Pathol. No. 23886-i) is typical of a benign exostosis, but even in a case like this it would be safer to remove the growth by chiseling through the shaft of the phalanx.

Exostosis and Myxoma. Fig. 56 (Pathol. No. 10150-i) was diagnosed from this *x*-ray a benign exostosis of the lower end of the femur. The surgeon in 1909 removed this apparently bony tumor piecemeal. There was recurrence and death in four years. I was unable to ascertain the details of the recurrence, but apparently there was no doubt about the recurrence in the region of the knee-joint, and death with symptoms of long involvement. When I restudied the tissues removed in this case definite areas of myxoma were found mixed with the cancellous bone.

Up to the present time this is the only case of exostosis in which I found areas of myxoma, and this is the only patient who has died of the disease.

Multiple Exostoses. This is a congenital disease of the skeleton of which I have now eight cases—a condition not at all difficult to recognize clinically and in the *x*-ray. It will not be discussed here. But as stated before, the multi-

plicity of bone lesions excludes sarcoma, and there is no difficulty in recognizing in the *x*-ray the multiple benign lesions of bone—exostosis and ostitis fibrosa, from metastatic bone lesions.

Periosteal Chondroma. Eight cases. These are to be distinguished from the exostosis because they are composed chiefly of cartilage in the central zone of the exosteal growth, while in the exostosis, if cartilage is present, it forms the capsule of the bony growth beneath.

This classification may be unnecessary. Perhaps all periosteal chondromas might be studied with exostosis. But I have placed them in a separate group, because of the importance and the frequency of the association of cartilage with myxomatous tissue. I have just shown that of eighty-nine true exostoses but one contained myxomatous tissue, while of fourteen chiefly cartilage exostoses no less than six contained myxomatous tissue, and when myxoma is present and the lesion is explored and not properly cauterized, there will be a recurrence leading to amputation or death. For this reason one should be more suspicious of the presence of myxomatous tissue in all apparently cartilage tumors, whether periosteal or central.

The pure periosteal chondromas among our cases have been distributed as follows: ribs three cases; femur one; tibia, os calcis, sacrum, metatarsus one each. As contrasted with myxoma all the periosteal chondromas are well, and whether the operation has been incomplete or complete, or whether the growth was removed piecemeal or entire. One case situated on the metacarpal bone recurred, but is well now (1920) six years after the removal of the recurrent tumor with preservation of the bone.*

There is nothing characteristic in the age of onset of the chondroma. The tumors may be of long or short duration. Fig. 57 (Pathol. No. 25766-ii) is the *x*-ray of a periosteal chondroma of the shaft of the femur. This picture should be compared with Fig. 14 (Pathol. No. 20209), a benign bone cyst. This huge periosteal chondroma shows all the

*Since writing this I have received data and specimen of a Recurrent Chondroma. A special report will be published on this type. July 15, 1920.

characteristics of a benign periosteal growth. The only periosteal sarcoma with much bone formation which gives a picture anything like this is Fig. 70 (Pathol. No. 23284-ix) (vi). The shadow of the outer bone capsule in this chondroma looks like the surface of a wart—a condition never present in a bone cyst. There is no destruction or infiltration of the shaft beneath. The most interesting feature is the definite abnormality of the shaft of the femur from which the cartilage growth apparently arises, suggesting a congenital defect. This patient was a girl aged sixteen, and had observed a lump on the medial side of the lower third of the femur for ten years. Recently she had been working as a sales girl and had found that standing produced pain; for the past three months the mass had been increasing in size and the pain getting worse. It was diagnosed by Dr. Baetjer an osteochondroma, and removed piecemeal by Dr. Reid of Johns Hopkins Hospital. The tumor is as large as two oranges; it is composed chiefly of cartilage with areas of cancellous bone, but in the tumor there are numerous cysts and soft gelatinous areas which in the fresh suggested to me myxomatous tissue. But frozen sections of these apparently myxomatous areas demonstrated them to be cartilage.

This case shows that one cannot with certainty differentiate softened cartilage areas from myxomatous tissue.

Periosteal Myxoma and Chondro-myxoma. Thirteen cases. Unfortunately in these cases, when operated upon, the dangerous nature of the myxoma was not recognized and in spite of the complete removal of the periosteal growth, there has been recurrence and death in all the cases followed.

Fig. 58 (Pathol. No. 6773) is the *x*-ray of an apparently innocent periosteal growth which microscopically proved to be a pure myxoma. The collar of periosteal bone is seen, the cortical bone beneath, perhaps slightly depressed, shows no infiltration or destruction, and the marrow cavity of the shaft of the humerus seems normal. This patient, a white

female, aged sixty years, gave a history of trauma to this arm three or four years before operation. Since this trauma there has been a local area of pain and tenderness in the region of the present tumor, but the lump had been observed but four months. The growth was removed piecemeal in 1905. The patient died in 1915, ten years later, with evident metatasis to the scalp and mediastinum. But, as there was no autopsy, we do not know the pathology of the metastatic tumor. Between 1905 and 1912 there were seven operations for recurrences, either in the soft parts or the humerus. All the recurrent tumors were pure myxomas. Finally in 1912 the arm was amputated at the shoulder-joint.

One could have no more impressive evidence that a myxoma for practical purposes is a malignant tumor. In the discussion of central myxomas I have recorded the fact that the only cures were those in which the involved bone had been removed by resection or amputation without exposure of the tumor tissue.

Periosteal Myxoma and Bone Cysts. Among the fifty-four cases of bone cysts, in only one did the local lesion in the *x*-ray suggest a periosteal lesion, and when this case came under my observation in 1913 I could not but recollect the disastrous result in the periosteal myxoma just described. For this reason I chiselled off the periosteal growth with a good margin of healthy bone beneath and did not see the tumor (Fig. 61) until after it had been removed. It then proved to be a benign bone cyst. Fig. 59 (Pathol. No. 10693-iii) is the *x*-ray of the lesion of the lower end of the fibula, and it does resemble the periosteal myxoma. Fig. 60 (Pathol. No. 10693-iii) is the *x*-ray after operation. This patient is well (1920) seven years after operation. She was a white female aged nineteen and had observed a swelling of the lower end of the fibula eleven months. There had been no pain and no definite history of trauma.

Periosteal Giant-cell Tumor. These are rare. We have

a record of but four cases: one involving the lower end of the ulna; two the tubercle of the tibia, and one involving the sacrum. We have not observed a case of this type since 1912. We have no *x*-rays of these cases. From the study of the gross specimens they are periosteal growths not associated with bone formation, similar to the epulis of the jaw. The bone beneath shows very little destruction. They can be recognized by their gross and microscopic appearance. The two cases involving the tubercle of the tibia demonstrate the importance of bearing this benign lesion in mind. The first case (Pathol. No. 1448) was first curetted, and even after a second curetting, remained well as long as it was followed, seven years. The second case also recurred after partial excision, was unnecessarily amputated. In both of these cases the tubercle of the tibia was destroyed by the periosteal growth, but examination of the case amputated demonstrates that the shaft beneath was not involved, and the local growth could have been resected. These patients were forty-eight and forty-five years of age; in one pain fourteen months, tumor four months; in the other pain two years, tumor one year. *In my series of cases these are the only tumors confined to the tubercle of the tibia.*

Enlargement of the tubercle of the tibia after slight trauma (fracture of the beak-shaped process, Schlatter-Osgood disease) is not an uncommon lesion and must be distinguished from tuberculosis, osteomyelitis and tumor. In the cases which I have observed the diagnosis was not difficult from the history and the *x*-ray.

The periosteal giant-cell tumor of the lower end of the ulna was of interest, because the tumor pulsated. This is the only pulsating tumor in the group which I have studied. (Reported in *Annals of Surgery,* August, 1912, Fig. 15.)

Periosteal Sarcoma. This is the most common neoplasm next to the exostosis, and the most fateful—less than four per cent. of cures.

X-ray Appearance of Periosteal Sarcoma. From the

x-ray standpoint these periosteal sarcomas may be divided into the following groups:

1. Cases in which the *x*-ray shows a typical radiating formation of periosteal bone, or a light fuzzy shadow with very slight destruction of the cortical bone beneath. This is perhaps the most common type, and in my experience is sufficiently characteristic to allow a positive diagnosis to be followed by resection or amputation without exploratory incision.

2. Here the periosteal new bone formation is so extensive that one must consider some type of exostosis or ossifying myositis. This form is rare.

3. Here the *x*-ray suggests osteomyelitis, because, in addition to the periosteal bone formation, the shaft shows light and dark areas: the light areas due to central destruction by the infiltrating tumor, the dark areas due to either periosteal or endosteal bone formation.

4. Here there is a palpable periosteal mass, but the *x*-ray shows no periosteal bone formation, no destruction of the cortical bone, but only changes in the marrow, or central, area due to infiltration by the tumor.

Group 1. Pathol. No. 15557-ix. Fig. 62 antero-posterior and Fig. 63, lateral view. The *x*-rays show, surrounding the lower end of the femur, above the epiphyseal line a few perpendicular rays of new bone formation, and in the antero-posterior view, above the internal condyle some fuzzy bone formation. In both views, especially the antero-posterior, the shadow of the internal condyle and the shaft above show irregular dark and light areas.

From my studies this case is typical of the *x*-ray of a periosteal sarcoma of the most malignant type. I have not an *x*-ray of syphilitic periostitis, osteomyelitis, or any type of benign periosteal growth which presents this peculiar combination of periosteal bone formation and changes from the normal in the shadow of the shaft.

Fig. 64 (Pathol. No. 15557-ix) is the photograph of a longitudinal section through the lower end of the femur.

It pictures the periosteal growth most marked in the region of the internal condyle, and the infiltration of the bone beneath, explaining the *x*-ray picture. The portion of the shaft above is uninvolved, both in the *x*-ray and in the specimen. This is confirmed by the microscope.

Clinical History. Pathol. No. 15557-ix. Figs. 62, 63, and 64. White male aged twenty-one; pain and swelling in region of knee and condyles present two and one-half months after trauma; diagnosed tuberculosis and treated without *x*-ray examination. This patient was referred to me in April, 1914, and the diagnosis of periosteal sarcoma was made from the *x*-rays (Figs. 62 and 63). Although I advised amputation rather than resection with bone transplantation, the patient chose the latter, and the specimen shows (Fig. 64) the resected bone denuded of its soft parts. Microscopically, the tumor was a mixed large-spindle-and-round-cell sarcoma with numerous giant mononuclear cells and with many giant cells of the giant-cell tumor type. There was both periosteal and exosteal bone formation, with here and there islands of epiphyseal cartilage. The bone transplantation from the tibia was successful, but four and one-half months later the patient requested amputation, preferring an artificial limb with a movable knee to the stiff joint. No tumor was found in the amputated leg. The patient died of metastasis two years and seven months after the first operation. Symptoms of lung metastasis were present about three months before death. The *x*-ray of the chest before operation and eighteen months later showed no evidence of metastasis.

Pathol. No. 25761. Fig. 65 is the *x*-ray of the upper end of the femur. It shows the fuzzy periosteal growth on the neck of the femur characteristic of the periosteal sarcoma. The perpendicular radiating bone formation is not present. The shadow of the neck and upper portion of the shaft between the trochanters is undoubtedly abnormal: mottled darker areas due to periosteal or endosteal bone formation, or to both. Fig. 66 is a photograph of a longitudinal sec-

tion through the femur and shows a pathological picture practically identical with that in the previous case. The diagnosis was made by Drs. Baetjer and Baer and a hip-joint amputation performed without exploratory incision.

The patient was a white male aged eighteen; there had been gradually increasing pain and stiffness for three months after a trauma. Microscopically it is a round-cell sarcoma with perithelial arrangement, and there is both endosteal and periosteal bone formation.

These two cases represent the most common form of periosteal sarcoma. In the next two cases the *x*-ray picture is not quite so typical and perhaps some benign form of ossifying periostitis should be considered.

Fig. 67 (Pathol. No. 24428-ix). This is the *x*-ray in which the shadow of the periosteal bone formation and the slight changes in the shaft of the fibula might be due to a syphilitic periostitis. Yet, clinically, there was a large palpable tumor of spindle shape surrounding the upper end of the bone. This tumor was resected by Dr. Winthrop of Mobile, Ala., without exploratory incision. The tumor (Fig. 68) is quite large, and bone formation is present only near the shaft. Microscopically, it is a mixed large-round and spindle-cell sarcoma with mononuclear giant cells, some periosteal and endosteal bone formation. In a similar case, I am inclined to think, it would be wiser before operation to give a therapeutic dose of salvarsan, even though the Wassermann is negative.

Fig. 69 (Pathol. No. 22795-ix). *X*-ray of the lower end of the femur. If one looks at the perpendicular ray-like bone formations above the external condyle with a fairly normal bone below, one might think of an exostosis of the osteochondroma type. I have never seen this ray formation so marked in syphilis. But when one looks at the entire picture and sees the shadow of a large periosteal growth with slight ray and foggy bone formation on the medial side and a shadow of the shaft undoubtedly darkened by periosteal bone formation, one can be pretty certain that

the lesion is a periosteal sarcoma of the most malignant and common type.

In this case Dr. Baetjer made the diagnosis of periosteal sarcoma, and Dr. Follis of Johns Hopkins Hospital amputated without exploratory incision.

The patient was a white male aged twenty-two; there is no history of trauma. He had had pain for two years; swelling for one year and eleven months; seven months after the onset of the pain, even though there was some little swelling, he was admitted into the U. S. Army and continued in full duty to about three months before operation; for six weeks there had been increased pain and swelling. Clinically there was a large spindle-shaped swelling surrounding the lower end of the femur. Microscopically, the tumor is a perithelial round-cell sarcoma.

Group 2. Excessive Periosteal Bone Formation. In this group there are perhaps seven cases, but only one good *x*-ray. Fig. 70 (Pathol. No. 23284-ix-vi) shows the *x*-ray of the lower end of the femur. The most marked feature is the periosteal bone formation of the lower third of the femur covering the condyle with no marked change in the shadow of the shaft. On the whole it represents ossifying myositis. On closer inspection of this *x*-ray one sees posterior, above the popliteal space, a circumscribed dark shadow containing some bone which suggests a portion of the tumor with less bone formation.

I saw this patient and the *x*-ray two years after the onset, and she died with symptoms of metastasis to the lung without operation about one year later. There is, first, an indefinite history of a lump in this region for twenty years following riding horseback and suggesting ossifying myositis. The present swelling is of two years' duration after an injury.

With rare exceptions the area of periosteal bone formation shown in the *x*-ray is very much smaller than the palpable periosteal tumor, but in cases of this kind the area of periosteal bone formation in the *x*-ray seems to correspond with the size of the palpable tumor.

On the lower jaw we have three cases of this type, and all have remained well since resection, but when present on the shaft of the femur (three cases: two lower end, one upper end) and on the upper end of the fibula (two cases) and on the rib or skull (each one case) these periosteal sarcomas with marked bone formation have been just as malignant as the other types of periosteal sarcoma. One was a small-round-cell sarcoma, a type usually not associated with much bone formation. The other cases were of the mixed spindle-and-round-cell type. It is difficult to explain the excessive bone formation in these seven cases of periosteal sarcoma. The only fact, up to the present time, that seems impressive is that as a rule the earlier you *x*-ray a periosteal sarcoma after the onset of the symptoms, the more often do you find periosteal bone formation. In later cases it is less frequent, but in Fig. 70 it was still present two years after onset. In periosteal sarcoma, with but few exceptions, the bone formation is present in the tumor near the shaft; in the periphery of the tumor there is little, if any, bone formation.

Group 3. *X*-ray picture like osteomyelitis. Fig. 71 (Pathol. No. 10537-ix). *X*-ray of a periosteal sarcoma of the upper third of the tibia. This *x*-ray was submitted to the members of the American Orthopedic Association ten years ago. In the group there was a number of roentgenologists and visiting surgeons from abroad. The diagnosis made was either syphilis or osteomyelitis; no one diagnosed sarcoma. The patient was a white male aged seventeen; pain six months; swelling five months. The patient died within one year after amputation. Microscopically, it is a small-round-cell sarcoma with myxomatous and fibro-spindle-cell areas; there is both periosteal and endosteal bone formation. Beneath the periosteal growth the shaft is involved to the marrow.

Fig. 72 (Pathol. No. 15745-ix) shows the *x*-ray of the upper end of the femur. This patient was under the observation of Dr. Danforth of Providence, R. I., who was rather inclined to the diagnosis of osteomyelitis. He explored and

removed a piece for diagnosis, and kindly sent the sections to me. The section shows largely new bone formation, but there is one area of undoubted small-round-cell sarcoma. Amputation was refused, and the patient died three months later of metastasis to the lung. The patient was fourteen years of age; pain eighteen months; swelling eight months.

This case demonstrates the difficulty of a differential diagnosis from the *x*-ray only.

Fig. 73 (Pathol. No. 23894-ix) is the *x*-ray of the upper end of the tibia. This was diagnosed chronic osteomyelitis by Baetjer, explored by Reid of Johns Hopkins Hospital in December, 1918; diagnosed sarcoma and amputation performed.

The patient was a white male aged fifteen; pain one year; swelling eight months. In the gross (Fig. 74) there was a small periosteal growth with a large area of involvement of the shaft and surrounding sclerosis. Microscopically, this is an alveolar round-cell sarcoma, suggesting endothelioma. There is both periosteal and endosteal bone formation.

In these last two cases (Figs. 72 and 73) diagnosed osteomyelitis the typical ray and fuzzy bone formation of periosteal sarcoma is absent. The marked features are widening and thickening of the shaft with mottled areas of bone destruction, mottled darker areas of bone formation, and definite thickening from periosteal bone formation. In the first case (Fig. 72) light areas of new periosteal bone formation are evident, but they do not take the shape of rays or of the fuzzy type.

In these cases of periosteal sarcoma diagnosed in the *x*-ray osteomyelitis the clinical picture was not that of osteomyelitis, and exploration would have differentiated at once.

Group 4. Periosteal sarcoma with no periosteal bone formation, but with evidence of marrow involvement in the *x*-ray. This is very rare.

Fig. 75 (Pathol. No. 25505-ix) is an *x*-ray sent to me by Dr. Danforth of Providence, R. I. The patient had a palpa-

ble mass in the soft parts about the lower end of the femur which had been present some months, and the question was as to the interpretation of the *x*-ray findings. I had never seen a picture like it and could not interpret it. Dr. Danforth explored the tumor and sent a piece of the tissue to me. It was spindle-cell sarcoma. A few weeks later pathological fracture occurred and the leg was amputated. I have not yet received the specimen, nor the full clinical history.

This case is a demonstration of what may be expected in the future, when as a routine *x*-rays will be taken in cases in which no *x*-rays have been taken before, and when we have the opportunity to *x*-ray bone lesions very quickly after the symptom of onset, we are to see pictures of bone changes with which our previous experience has not made us familiar, and until we have a large experience, diagnosis will be more difficult in this early stage.

Periostitis

I have a few cases of different types of periostitis, which have been diagnosed from the *x*-ray sarcoma, and in a few of these the piece excised has been diagnosed microscopically sarcoma. These cases may be classified as follows:

1. Traumatic Ossifying Periostitis.
2. Syphilitic Ossifying Periostitis.
3. Pyogenic Ossifying Periostitis, associated with osteomyelitis.
4. Ossifying Periostitis about tubercular lesions of bone.
5. Ossifying Periostitis associated with benign tumors near bone.

1. *Traumatic Ossifying Periostitis.* Fig. 78 (Pathol. No. 10313 BD) is an *x*-ray picturing a localized periosteal growth from the shaft of the mid-humerus and also a periosteal growth from the shaft of the clavicle near the acromial process. Ten years ago this was first diagnosed periosteal sarcoma, and the piece removed was diagnosed spindle-cell sarcoma; amputation of the shoulder-joint advised. I saw this patient in 1910. The surgeon and the

roentgenologist who examined this patient first apparently did not see the lesion of the clavicle. The two definite periosteal lesions, in my experience, excluded sarcoma, and this has been confirmed in the cases observed since. The section of the piece excised showed new periosteal bone imbedded in granulation tissue. This patient is well with good function, in 1920—ten years; he is an officer in the U. S. Army.

When I saw him in 1910 he was seventeen years of age and had received a severe contusion of the shoulder and arm in a football scrimmage. Three weeks later, after the first marked swelling and echymosis had disappeared, a nodule could be palpated attached to the shaft of the humerus, as shown in the *x*-ray, and this was immediately explored.

X-ray of Bones and Joints After Trauma. In view of the fact that the majority of benign and malignant bone lesions give a history of trauma and very few a history of fracture, it seems to be of the greatest importance that an *x*-ray should be taken after such bone and joint injuries not associated with fracture and dislocation, and that this *x*-ray examination be continued until all symptoms have disappeared. The moment the *x*-ray shows any change of bone production or bone destruction there should be immediate investigation to establish the pathology.

I have already called attention to the fact that in the true exostosis a history of trauma or fracture is unusual, and have been surprised at the infrequency of periosteal bone formation after trauma. In a large number of cases I have *x*-ray studies after trauma and at intervals until all symptoms had disappeared, with negative findings. In only one case (Fig. 11) (Pathol. No. 20115, pages 172 and 179) in which the *x*-rays were negative after the injury, did a later *x*-ray picture show the development of the malignant hemorrhagic cyst in the outer condyle of the femur.

I have also called attention to the changes that may take place in the cancellous bone of the epiphysis after traumatic arthritis (Fig. 22) (Pathol. No. 23881, page 154). The first

changes apparently are an osteoporosis due to lipomasia, the result of non-use; then mottled dark areas due to regeneration of bone secondary to beginning function. The diagnostic point here is that all the bones contiguous to the joint are involved.

Pain and Tenderness After Trauma. I have a number of observations which demonstrate that localized pain and tenderness without swelling may persist months, even up to nine, after a contusion of a bone with negative *x*-ray findings. Cases of this kind should be carefully watched and frequently *x*-rayed. That benign ossifying periostitis may follow trauma is illustrated in Fig. 78 of the football player, and the shadow may simulate periosteal sarcoma.

2. *Syphilitic Ossifying Periostitis.* When the syphilitic bone lesions are multiple, sarcoma can be excluded. But often this lesion involves a single bone. In all of my cases, except one, the Wassermann was positive and the bone lesion has shown almost immediate improvement after salvarsan. In one case it was negative, but the bone lesion of the tibia responded immediately to salvarsan. In this case the *x*-ray had been diagnosed sarcoma and amputation advised.

Fig. 79 (Pathol. No. 11769-BD) and Fig. 80 show a photograph of the forearm and the *x*-ray of the involved ulna in which a diagnosis of sarcoma had been made, both from the *x*-ray and from a piece excised. I saw this patient in 1911 because amputation of the arm had been advised. Surrounding the lower end of the ulna was a spindle swelling supposed to be typical of periosteal sarcoma. The *x*-ray shows chiefly bone destruction, but there is undoubted thickening of the lower end of the ulna due to periosteal and perhaps endosteal bone formation. As the exploratory incision had not entered the shaft of the ulna, these light areas of bone destruction cannot be explained by removal of tissue at operation.

This *x*-ray should be compared with Fig. 73 and Fig. 76, both periosteal sarcoma, and Fig. 83 (JCB. No. 8415), pyogenic osteomyelitis.

The patient under discussion was a white male aged seventeen. There was no definite history of trauma. For eight months he had had restricted supination of the forearm followed by swelling of the lower end of the ulna. At the end of two months an *x*-ray was taken and a piece excised, sarcoma diagnosed, and treatment by Coley's serum tried. As there was no improvement after six months, amputation was advised. No examination of the blood had been made. Our routine Wasserman examination in this case was positive, and the swelling rapidly disappeared under salvarsan treatment. The syphilitic infection was probably congenital in origin, because the father and two brothers also gave positive Wassermanns. This patient is well now (1920) nine years.

This observation demonstrates that a routine Wassermann in bone lesions is as essential as a routine *x*-ray, and in periosteal lesions it is my opinion that a therapeutic dose of salvarsan should be given even when the Wassermann is negative.

3. *Pyogenic Ossifying Periostitis.* It is almost unique in infections of bone with organisms other than with the spirochaeta and gonococcus, to observe periosteal involvement without marrow, or central, involvement. In many cases of syphilis the entire change is seen in the periosteal bone formation with or without slight destruction of the cortical layer. The most frequent situation of ossifying gonorrhaeal periostitis is the os calcis. In all the cases of gonorrhoeal periostitis with periosteal bone formation which I have studied more than one bone have been involved, and this when the clinical picture had excluded sarcoma. In the cases of ossifying periostitis of the os calcis apparently due to the gonococcus the lesion has usually been bilateral, and up to the present time I have never observed a periosteal sarcoma of the os calcis, nor in any of the tarsal or carpal bones. There is one periosteal sarcoma of the metatarsus.

Fig. 81 (Pathol. No. 16865) is the *x*-ray of a unique case.

Here there is definite periosteal bone formation of the upper third of the femur with some destruction of the cortical layer, but apparently an uninvolved marrow cavity. There was a palpable spindle swelling about the shaft of the upper third of the femur, much larger than the area pictured in the *x*-ray. Clinically, it was the picture of a periosteal sarcoma. When I observed this patient in 1914 I was less familiar with the *x*-ray appearance of periosteal sarcomas than I am today, and I was suspicious of a sarcoma. Since then when I compare this *x*-ray with every case of periosteal sarcoma confirmed by pathological diagnosis and death from the disease, it seems to present differences. But whether sarcoma could be excluded if a similar case came under observation today, I am by no means certain. This patient was a white male aged forty-two: the only fact in his history, never yet recorded in a periosteal sarcoma, was the presence of a carbuncle on the inner side of the lower third of the left thigh. This carbuncle began five months before I saw the patient and healed without operation in two weeks. Then there was pain in the upper third of the thigh followed by swelling below the trochanter. The Wassermann was negative. The resident surgeon at St. Agnes Hospital told this patient that the leg would probably have to be amputated at the hip. The patient immediately left the hospital, went to another hospital where a piece was excised for diagnosis and diagnosed sarcoma. The tissue was sent to the laboratory, and I have submitted the sections to a number of pathologists. The majority were of the opinion that the lesion is sarcoma, although this section does not resemble any sarcoma which I have studied, but rather the picture of spindle-cell granulation tissue in which there is imbedded much new bone. Some two years later the patient again came under my observation, apparently well, and the *x*-ray shows (Fig. 82) that the lesion has practically healed, but there is still thickening. This patient is well today, six years since he was first seen by me.

A case of this kind demonstrates that some of the so-called

cures of periosteal sarcoma after amputation, serum, x-ray, or radium belong to this type of periosteal lesion. How frequently it occurs, I am unable to determine. Had I amputated in this case and taken the majority diagnosis of the section, this patient could be placed as the third cure of periosteal sarcoma.

Fig. 83 (JCB. 8415) is an *x*-ray of a lesion in the lower third of the ulna which resembles somewhat periosteal sarcoma with marrow involvement, or syphilis. Clinically, on account of the slight fever and leucocytosis, it suggested pyogenic osteomyelitis. The symptoms—pain and swelling —had been present about two months. The exploration found a pus cavity surrounded by granulation tissue with no pus formation outside the bone. The lesion healed promptly and the patient has remained well.

4. *Ossifying Periostitis About Tubercular Lesions of Bone.* Fig. 84 (Pathol. No. 24311) is an example of extensive periosteal bone formation associated with a tubercular arthritis of the metacarpo-carpal joint of the thumb. In this *x*-ray the destruction of the articular surface of the bones in this joint associated with periosteal bone formation about the shaft of the metacarpal bone exclude sarcoma. In this case the patient was first operated on for tuberculosis of the tendon-sheath of the extensor to this thumb over this joint. At this time and for some months later the *x*-ray of the hand showed no bone changes. In order to save the tendon, the tubercular tissue could not be completely removed. Later the *x*-ray showed the joint destruction, and the periosteal bone formation. Only the joint involvement was excised. The wound has now healed, the periosteal bone formation has almost disappeared, and the function of the thumb is unimpaired.

The repeated *x*-ray examinations in this case undoubtedly allowed the early recognition and prompt treatment of the tubercular joint infection.

I have no cases of tuberculosis of bone diagnosed sarcoma because of periosteal involvement. I have already

discussed those few cases of tuberculosis of the central or epiphyseal area of bone without periosteal changes which have been diagnosed from the *x*-ray central sarcoma.

5. *Ossifying Periostitis Associated with Benign Tumors Near Bone.* This is unusual. Fig. 85 (Pathol. No. 24367) is an *x*-ray showing periosteal bone formation from the shaft of the lower end of the femur, and from the position of the periosteal shadow this new bone formation might be within the capsule of the joint. This patient was referred to me by Dr. Hoke of Atlanta, Ga. In April, 1919, Dr. Hoke removed from the knee-joint near the patellar tendon a tumor about the size of the end of an adult thumb. This tumor is a chondroma. The patient gave a history of pain and stiffness of the right knee for two years with attacks of intermittent hydrops. The tonsils had been removed, and the knee put in plaster. Later Dr. Hoke found the tumor and removed it. Five months after this operation I examined the patient and the *x*-ray and in view of the fact that the tumor removed from the knee-joint was a pure chondroma, I advised against exploring because of the *x*-ray picture. This patient in April, 1920, seven months later, is very much better, but the shadows of bone formation still persist.

Fig. 86 (Pathol. No. 23323) is an *x*-ray of the skull showing a bone defect in the frontal above the right eyebrow. This patient was operated on by my colleague Dr. Seegar at St. Agnes in June, 1918, almost two years ago. The patient was a white girl aged ten, and had observed a swelling above the right eyebrow for two months. The swelling was about the size of a fifty-cent piece, the skin normal. It was distinctly compressible, and one could feel the edges of the bone defect. At the operation by Dr. Seegar the fresh appearance of the tumor tissue suggested sarcoma. For this reason he felt that it was inoperable and only partially removed it. From my study of the section I was inclined to the diagnosis of a capillary angioma. The Wassermann in this case was negative. There has been no re-

currence within one year; the bone defect has completely healed and now, almost two years since operation, there is no sign of recurrence.

Here, therefore, we have another observation which could be easily diagnosed sarcoma and recorded as a cure after any method of treatment.

Quite recently there was referred to me an adult with a large fluctuating swelling above the left eyebrow of one month's duration, and the *x*-ray showed a similar defect in the frontal bone. In the beginning there had been intense pain in the eyebrow; then swelling with relief of pain; then fluctuation with redness of the skin—the clinical picture of an abscess. In addition to the bone defect, the *x*-ray showed cloudiness of the frontal sinus. Incision found a pus cavity lined by hemorrhagic granulation tissue, the sections from which somewhat resembled sarcoma. The wound healed rapidly after incision, and the patient is now well in spite of the fact that he refused to have the sinus drained through the nose. The pus contained many cocci in cover slips. Unfortunately cultures, although made, were not carried through in the laboratory.

Conclusions. In spite of a more or less continuous study of lesions of bone for twenty-seven years based upon clinical, pathological and later *x*-ray investigation, and in spite of a thorough reading of the literature which has been critically reviewed in the December numbers of *Progressive Medicine* from 1899 to 1918, I find myself unable to summarize the results of this study in a short number of concluding remarks.

The most striking fact is the absence of solid central sarcoma in recent years. The relative number of periosteal sarcoma and malignant bone cysts and of all other types of benign and malignant bone lesions continue in about the same relative proportion, but cases in which we can make a diagnosis of central sarcoma are conspicuous by their absence. It is true that when we have both a periosteal and central neoplasm with more or less destruction of the cor-

tical bone, we have classed these with periosteal sarcoma and for practical purposes they are that.

I would welcome an opportunity to study a solid central sarcoma in which there is no periosteal growth.

At the present time the diagnosis of a bone lesion, especially in its early stage, in the great majority of cases must be made at the exploratory incision, and in making this incision the surgeon should be prepared to prevent the dissemination of tumor tissue, especially of myxoma, into the exposed normal tissues. This is most important when the lesion can be removed by local resection rather than amputation. The greatest danger appears to be in myxoma. The technique of destruction of the tumor tissue exposed is the immediate application of pure carbolic acid followed by alcohol and the temporary packing of the wound with a piece of gauze saturated with a fifty per cent. solution of chloride of zinc, or, in suitable cases the use of the electric cautery. If possible the operation for removal should follow immediately after the diagnosis from the gross appearance and the frozen section.

This destruction is not essential in the bone cyst. Apparently in the giant-cell tumor it adds to the success of curetting. It apparently is life saving in the myxoma. The number of cures in periosteal and central sarcomas are too few to estimate the danger of exploratory incision without such destruction. Of the four cured cases (five years) two had pieces excised for diagnosis with an interval before amputation.

The present results of surgery for periosteal and central sarcomas do not offer very much. I am not prepared to discuss the results of *x*-ray, radium, and serum, but I can find no evidence that these agents have any effect upon the lung metastasis, and this is the cause of death.

Apparently the only hope rests on earlier recognition and proper intervention. *The disease must be eradicated locally before metastasis.*

In view of the frequency of benign periosteal and central

bone lesions and the small per cent. of cures in malignant lesions, any mutilating operation, such as amputation or extensive resection, is not justifiable until the diagnosis is accurately made. If there is any doubt as to the diagnosis of malignancy, the lesion should be treated as if it were benign.

In the past there is no question that many amputations and extensive resections have been done for benign lesions, especially the bone cyst and giant-cell tumor, and many surgeons have gotten a wrong impression as to the probabilities of a cure, because these patients have remained well with a diagnosis of sarcoma.

NOTE: The following illustrations have been reproduced from photographs made by Mr. Herman Schapiro.

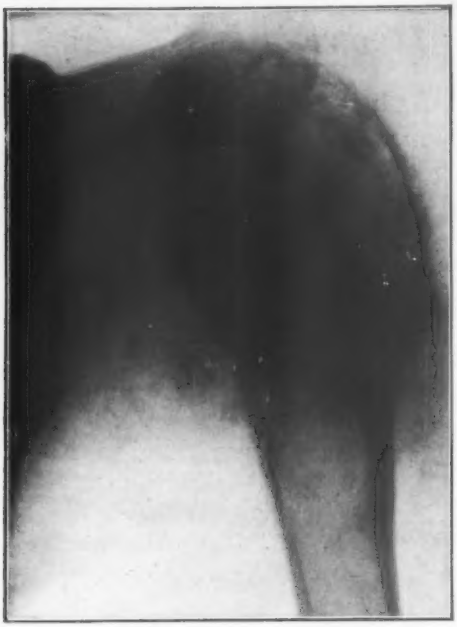

Fig. 1. Path. No. 19133 (VII). Central Myxo-sarcoma. Greater tuberosity of humerus. See page 175.

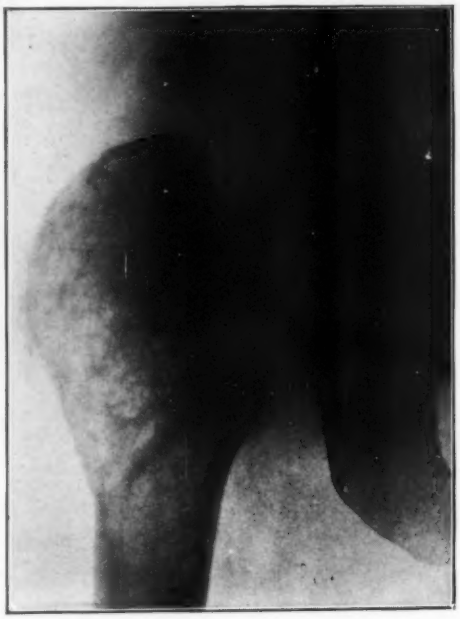

Fig. 2. Path. No. 17871 (III). Benign bone cyst Trochanter Femur. See pages 168 and 175.

Fig. 3. Path. No. 7964 (X). Central Sarcoma. Upper end of Fibula. Plate taken many years ago, poor. See pages 166 and 176.

Fig. 4. Path. No. 12926 (V). Central Giant Cell Tumor. Upper end of Fibula. See pages 166 and 176.

Fig. 5. Path. No. 16297 (III). Benign Bone Cyst. Upper end of Tibia. See page 176.

Fig. 6. Path. No. 12276 (V). Central Giant Cell Tumor. Upper end of Tibia. See page 176.

Fig. 7. Path. No. 13092 (X). Central Sarcoma. Upper end of Tibia. Diagnosed Osteomyelitis. See page 177.

Fig. 8. Path. No. 3931 (X). Central Sarcoma. Upper end of Tibia. Showing perforation of cortical bone with formation of periosteal tumor. See page 178.

Fig. 9. Path. No. 9881 (V). Central Giant Cell Tumor, Inner Condyle Femur. See page 178.

Fig. 11. Path. No. 20115 (XIII). Malignant Central Bone Cyst. Outer Condyle Femur. See pages 172 and 179.

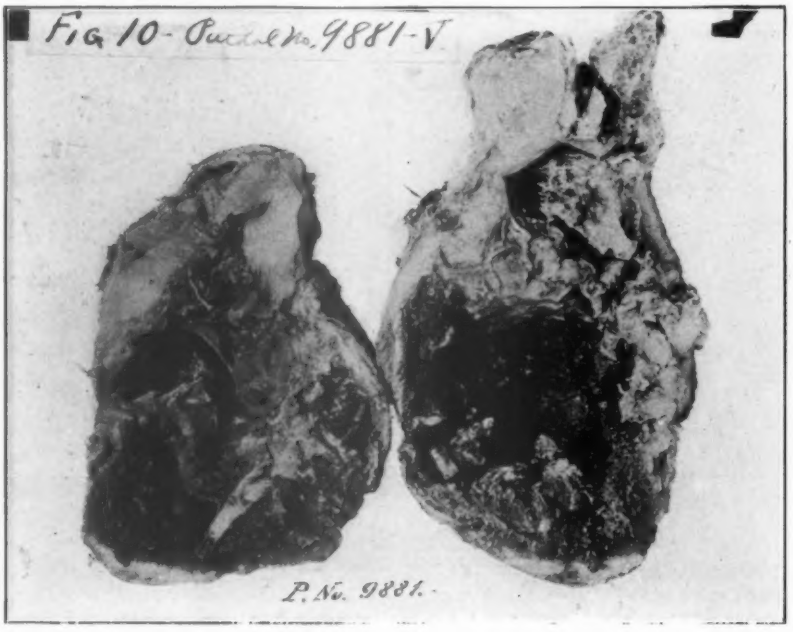

Fig. 10. Path. No. 9881 (V). Central Giant Cell Tumor. Inner Condyle of Femur. Photograph of specimen removed. See Fig. 9.

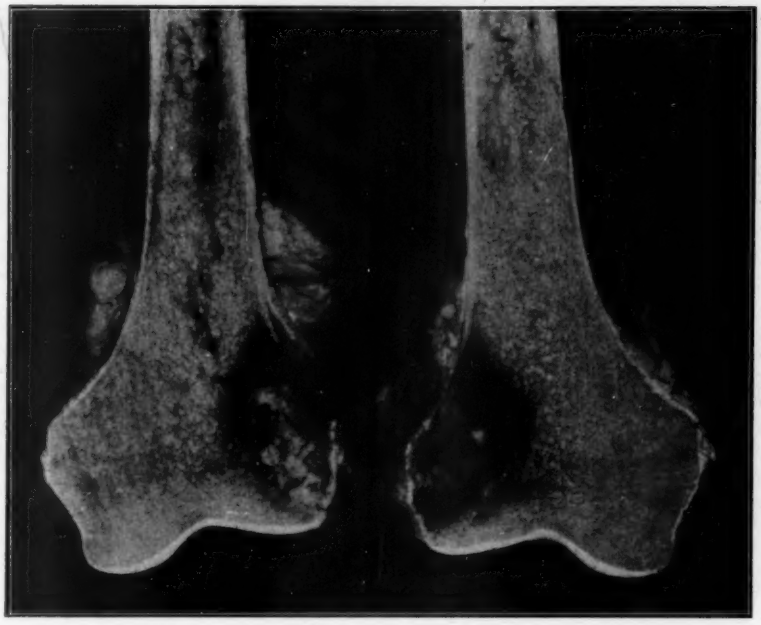

Fig. 12. Path. No. 20115 (XIII). Malignant Central Bone Cyst. Outer Condyle Femur. Gross Specimen. See Fig. 11. (Page 179.)

No. 13. Path. No. 20646 (III). Benign Bone Cyst. Lower end of Femur. (Huge size.) See pages 168 and 179.

Fig. 14. Path. No. 20209 (III). Benign Bone Cyst. Shaft of Femur (Huge). See page 180.

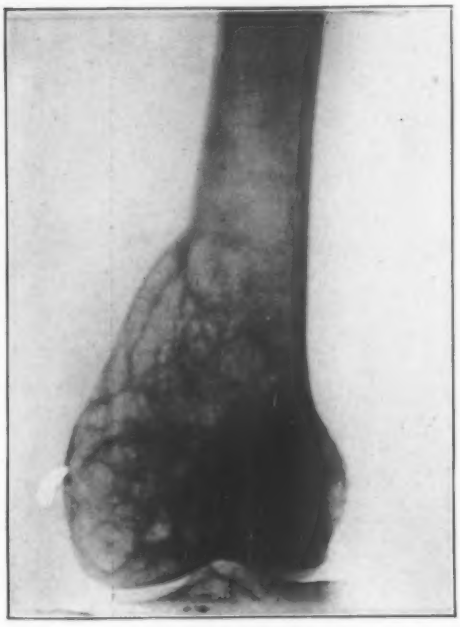

Fig. 15. Path. No. 22016 (II). Central Chondroma lower end of Femur. See page 180.

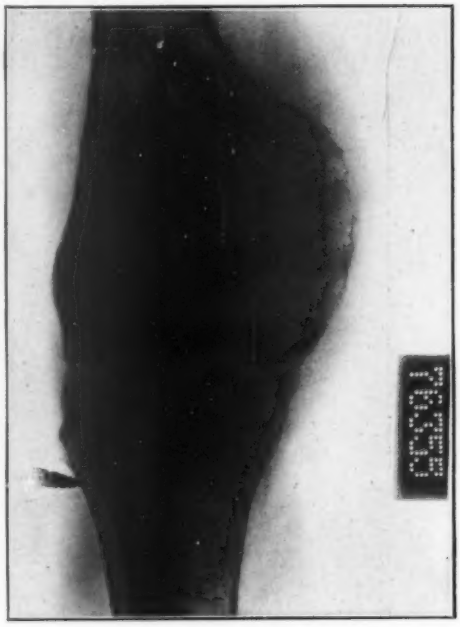

Fig. 16. Path. No. 25778 (V). Central Giant Cell Tumor. Lower end of Femur. See page 180.

Fig. 17. Path. No. 25778 (V). Central Giant Cell Tumor. Lower end of Femur. See page 180.

Fig. 18. Path. No. 23407 (VIII). Central Fibro-sarcoma. Lower end of Femur. See page 181.

Fig. 19. Path. No. 23407 (VIII). Central Fibro-sarcoma. Lower end of Femur. For *x*-ray see Fig. 18.

Fig. 20. Path. No. 14229 (XIII). Malignant Central Bone Cyst. Lower end of Femur. See pages 152 and 153.

Fig. 21. Path. No. 14229 (XIII). Malignant Central Bone Cyst. Lower End of Femur. Gross Specimen. See Fig. 20 and page 154.

Fig. 22. Path. No. 23881. *X*-Ray of Bone Changes in Traumatic Arthritis. See page 154.

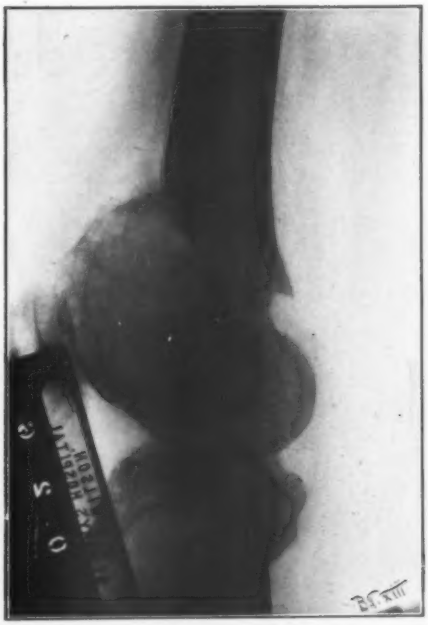

Fig. 23. Path. No. 19179 (XIII). Central Malignant Bone Cyst. Lower end of Femur. See page 182.

Fig. 24. Path. No. 19179 (XIII). Central Malignant Bone Cyst. Lower end of Femur. See Fig. 23.

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Fig. 26. Path. No. 10602 (XIII). Central Malignant Bone Cyst. Shaft of Humerus. Pathological Fracture. See pages 151 and 171.

Fig. 27. Path. No. 10929 (III). Central Benign Bone Cyst. Shaft of Humerus. Pathological Fracture. Cured 10 years by removal of fluid only.

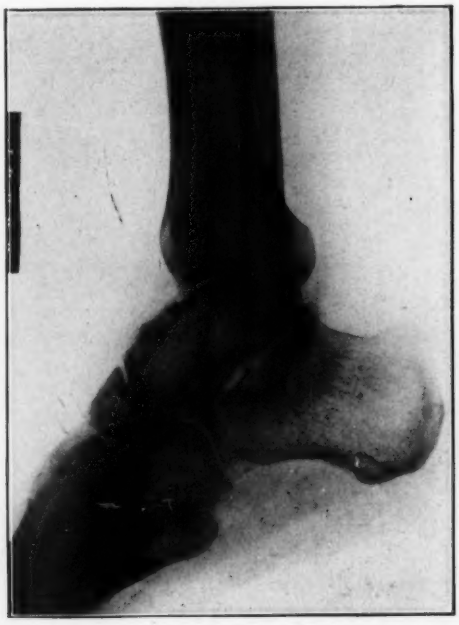

Fig. 28. Path. No. 22929 (II). Central Myxoma. Astragalus. Operation —Removal of bone piecemeal. See pages 155 and 156.

Fig. 29. Path. No. 22929 (II). Central Myxoma—Astragalus. Photograph of Gross specimen recurrent tumor after removal of Astragalus. See Fig. 28.

Fig. 30. Path. No. 22929 (II). Metastatic Myxoma Tubercle of Tibia after amputation of leg for recurrent myxoma in ankle joint. See Figs 28 and 29.

Fig. 31. Path. No. 17436 (V). Central Giant Cell Tumor. Os Calcis. Compare with Fig. 28. Patient of Dr. Prince, Rochester, N. Y. Curetted. Cured.

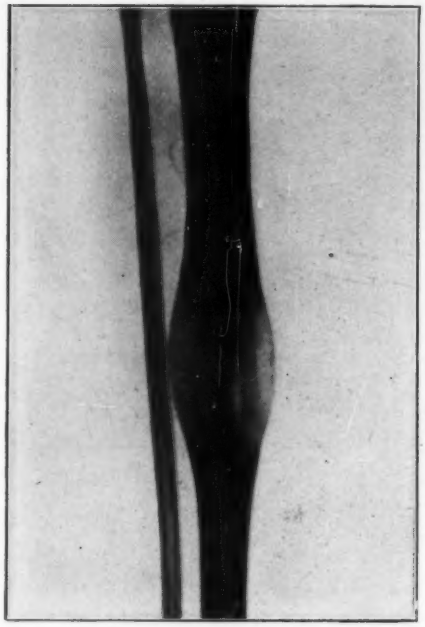

Fig. 32. Path. No. 24096 (III). Central Solid Ostitis Fibrosa. Shaft of Tibia. See page 163.

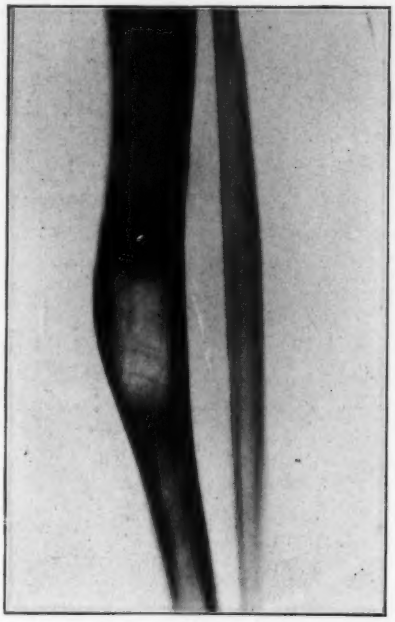

Fig. 33. Path. No. 24096 (III). Central Solid Ostitis Fibrosa. Shaft of Tibia. See Fig. 32.

Fig. 34. Path. No. 25542 (III). Central Solid Ostitis Fibrosa. Shaft of Tibia with evidence of bending and healing. See page 164.

Fig. 35. Path. No. 25109 (III). Central Solid Ostitis Fibrosa. Shaft of Tibia. Bending with evidence of ossification. Of interest because lesion present at birth. Operation at age 18 mos. Patient of Dr. Neil of Washington, D. C.

Fig. 36. Path. No. 21191 (III). Central Benign Bone Cyst. Lower end of Radius. See page 184.

Fig. 37. Path. No. 23552. Tuberculosis of lower end of radius and phalanx of index finger involving joint. See page 185.

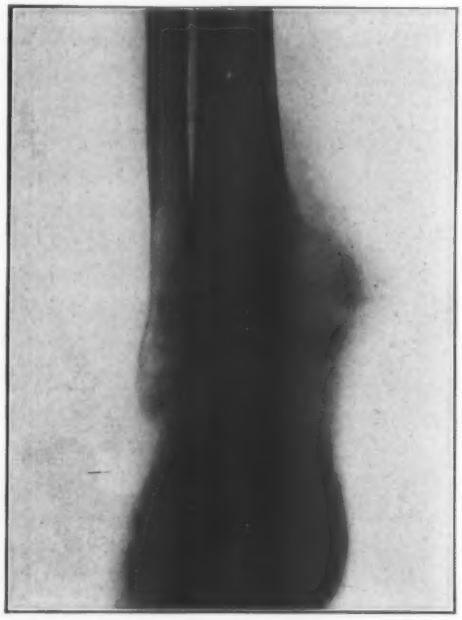

Fig. 38. Path. No. 23895. Tuberculosis of internal malleolus of tibia. See page 185.

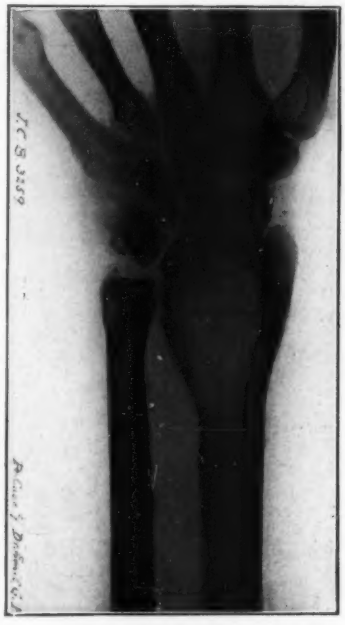

Fig. 39. Path. No. 12927. Central giant-cell tumor of lower end of radius. See page 185.

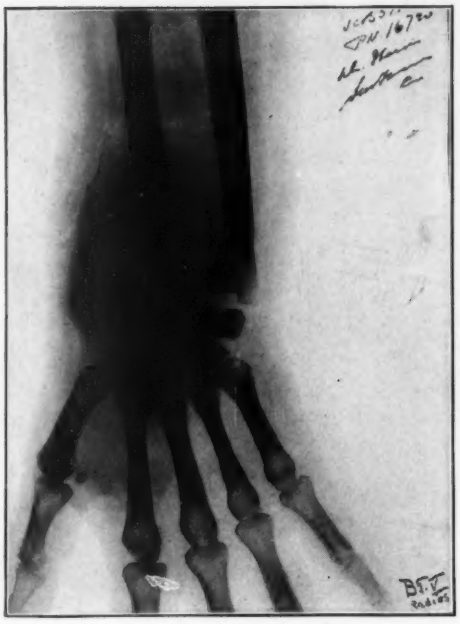

Fig. 40. Path. No. 16720 (V). Giant-cell tumor of lower end of radius. Marked expansion of bony shell. Patient of Dr. Sherman of San Francisco. Page 185.

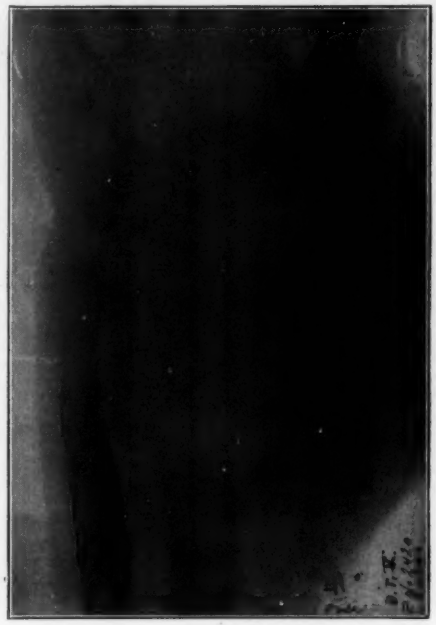

Fig. 41. Path. No. 2420 (V). *X*-ray of giant-cell tumor of lower end of radius with complete destruction of bone shell. See Figs. 42 and 43. Page 185.

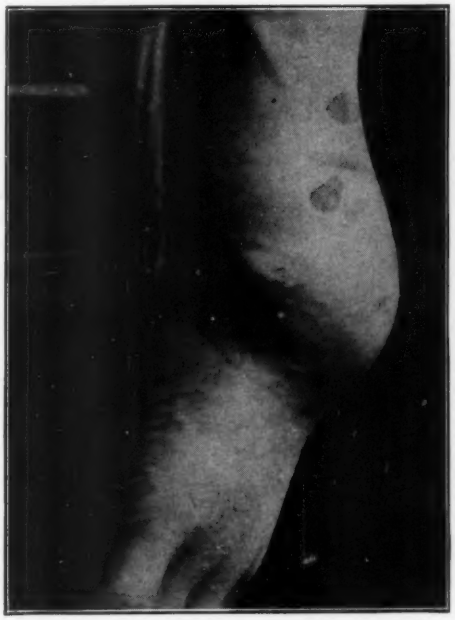

Fig. 42. Path. No. 2420 (V). Photograph of forearm the *x*-ray of which is shown in Fig. 41.

Fig. 43. Path. No. 2420 (V). Photograph of gross specimen. Giant-cell tumor of lower end of radius. For *x*-ray see Fig. 41.

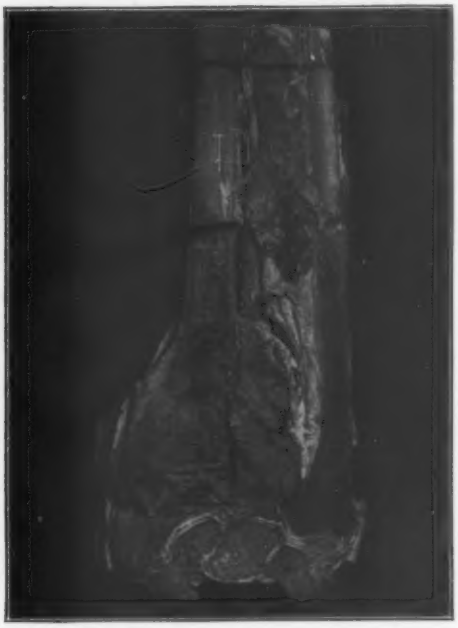

Fig. 44. Path. No. 1815 (V). Photograph of specimen of giant-cell tumor of lower end of radius. Page 185.

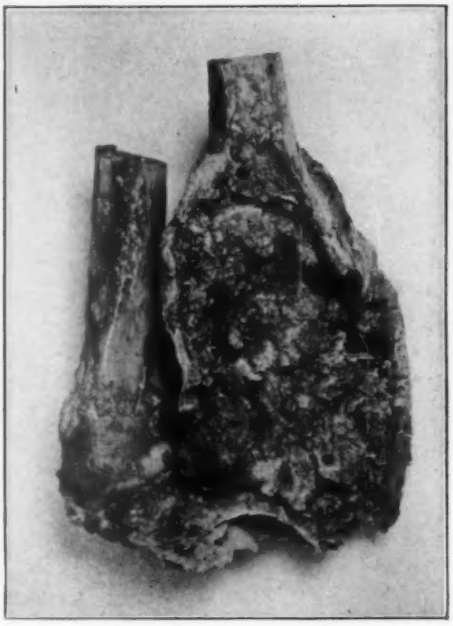

Fig. 45. Path. No. 6125 (V). Photograph of specimen of giant-cell tumor of lower end of radius.

Fig. 46. Path. No. 24682 (V). *X*-ray of giant-cell tumor of metacarpal bone of middle finger. Diagnosed sarcoma. Amputation. Page 187.

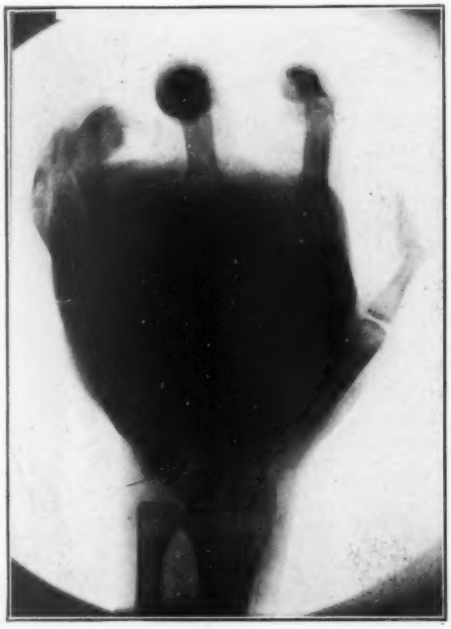

Fig. 47. Path. No. 24682 (V). Antero-posterior view of case shown in Fig. 46.

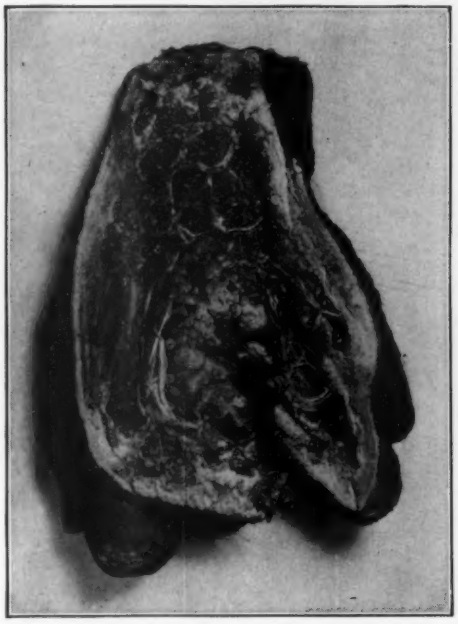

Fig. 48. Path. No. 24682 (V). Longitudinal section through hand. Giant-cell tumor, to demonstrate that the tumor could have been removed locally. See Figs. 46 and 47 for *x*-ray, and page 187.

Fig. 49. Path. No. 24682 (V). Photograph of gross specimen, surface view after removal of skin. See Figs. 46, 47, and 48.

Fig. 50. Path. No. 9025 (III). Benign bone cyst of upper end of ulna. Patient of Dr. Colvin of St. Paul, Minn. White female aged six years; swelling seven months. This *x*-ray was taken in 1904. For result (1920) see Fig. 51.

Fig. 51. Path. No. 9025 (III). *X*-ray (1920) fourteen years after *x*-ray shown in Fig. 50 demonstrating spontaneous healing of bone cyst without operation.

Fig. 52. Path. No. 17671 (XII). Central sarcoma of upper end of radius. Complete destruction of bone. The tumor shows a shadow. For gross specimen see Fig. 53. (Pages 178 and 183.)

Fig. 53. Path. No. 17671 (XII). Photograph of gross specimen. For *x*-ray see Fig. 52. White female aged sixty-five; pain six months; swelling six weeks.

Fig. 54. Path. No. 6367 (I). Benign exostosis of ilium. No operation. Recovery. See page 191.

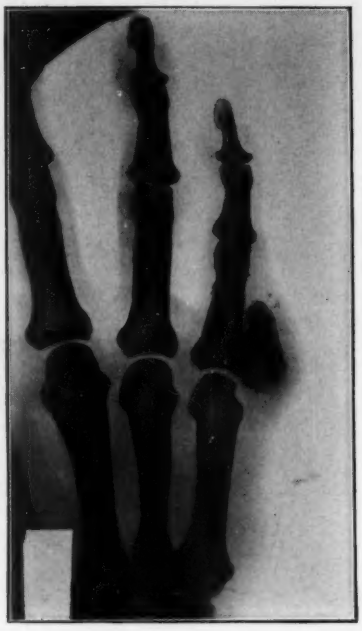

Fig. 55. Path. No. 23886 (I). Benign exostosis of phalanx. See page 191.

Fig. 56. Path. No. 10150 (I). Diagnosed benign exostosis of femur. Removed piecemeal. Myxoma found mixed with cancellous bone. Local recurrence and death. See pages 190 and 191.

Fig. 57. Path. No. 25766 (II). Periosteal osteochondroma of shaft of femur. See page 192.

Fig. 58. Path. No. 6773 (II). Periosteal myxoma of shaft of humerus. Compare with Fig. 59, see page 193.

Fig. 59. Path. No. 10693 (III). Benign bone cyst of lower end of fibula. *X*-ray suggesting periosteal myxoma. Compare with Fig. 58. See page 194.

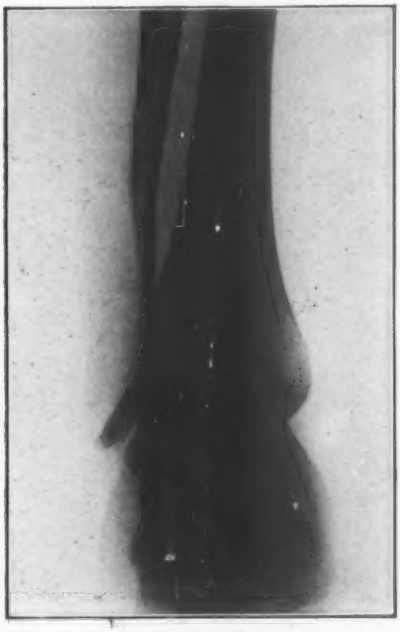

Fig. 60. Path. No. 10693 (III). *X*-ray after operation. (See Fig. 59.)

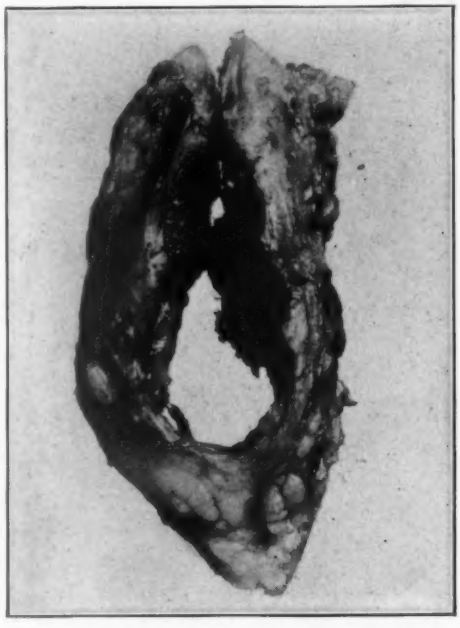

Fig. 61. Path. No. 10693 (III). Photograph of specimen. Benign bone cyst showing zone of healthy tissue about the tumor. See Figs. 59 and 60.

Fig. 62. Path. No. 15557 (IX). Periosteal sarcoma of lower end of femur. See page 196.

Fig. 63. Path. No. 15557 (IX). Lateral view. (See Fig. 62.)

Fig. 64. Path. No. 15557 (IX). Gross specimen of case shown in Figs. 62 and 63.

Fig. 65. Path. No. 25761 (IX). Periosteal sarcoma of neck of femur. See page 197.

Fig. 66. Path. No. 25761 (IX). Periosteal sarcoma. For *x*-ray see Fig. 65.

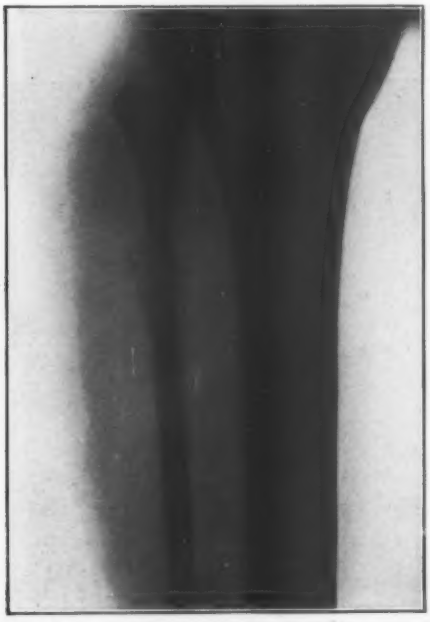

Fig. 67. Path. No. 24428 (IX). Periosteal sarcoma of upper end of fibula. See page 198.

Fig. 68. Path. No. 24428 (IX). Gross specimen. For *x*-ray see Fig. 67. Fibula surrounded by periosteal growth.

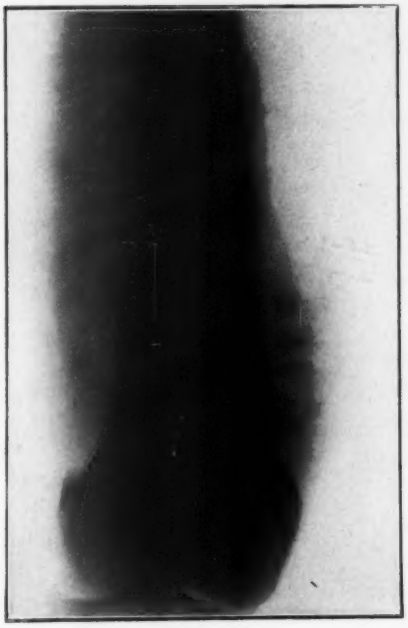

Fig. 69. Path. No. 22795 (IX). Periosteal sarcoma of lower end of femur. See page 198.

Fig. 70. Path. No. 23284 (IX). Periosteal sarcoma with excessive bone formation, suggesting ossifying myositis. See pages 193 and 199.

Fig. 71. Path. No. 10537 (IX). Periosteal sarcoma of upper third of tibia. Diagnosed osteomyelitis and syphilis. See page 200.

Fig. 72. Path. No. 15745 (IX). Periosteal sarcoma of upper end of femur, resembling osteomyelitis. See page 200.

Fig. 73. Path. No. 23894 (IX). Periosteal sarcoma of upper end of tibia. Diagnosed osteomyelitis. See page 201.

Fig. 74. Path. No. 23894 (IX). Periosteal sarcoma of upper end of tibia. Gross specimen. For *x*-ray see Fig. 73.

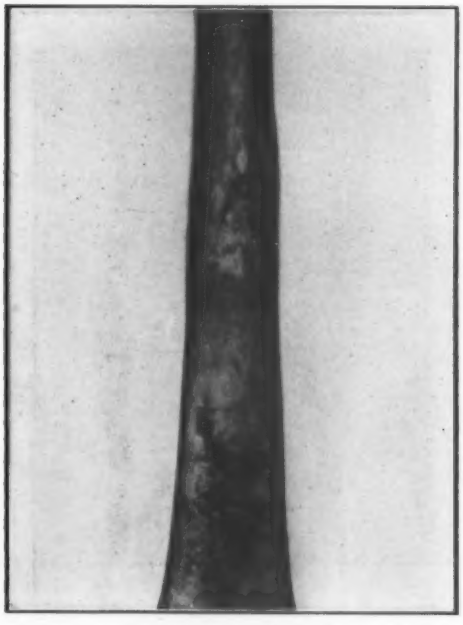

Fig. 75. Path. No. 25505 (IX). Periosteal sarcoma of lower end of femur. No *x*-ray evidence of periosteal tumor, only of the marrow invasion. See page 201.

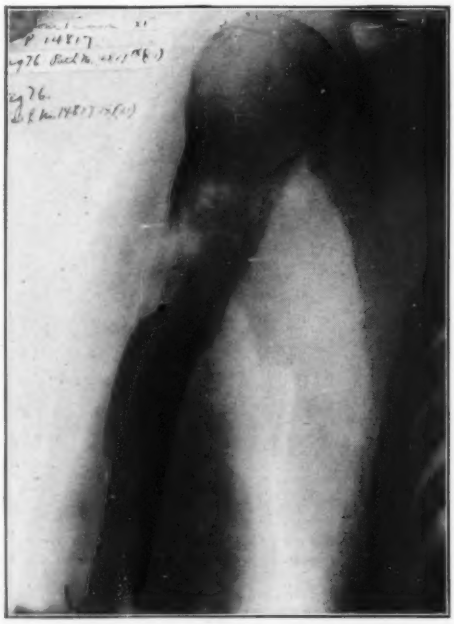

Fig. 76. Path. No. 14817 (IX). Periosteal sarcoma of shaft of humerus. Practically no periosteal bone formation, only destruction of shaft. For gross specimen see Fig. 77.

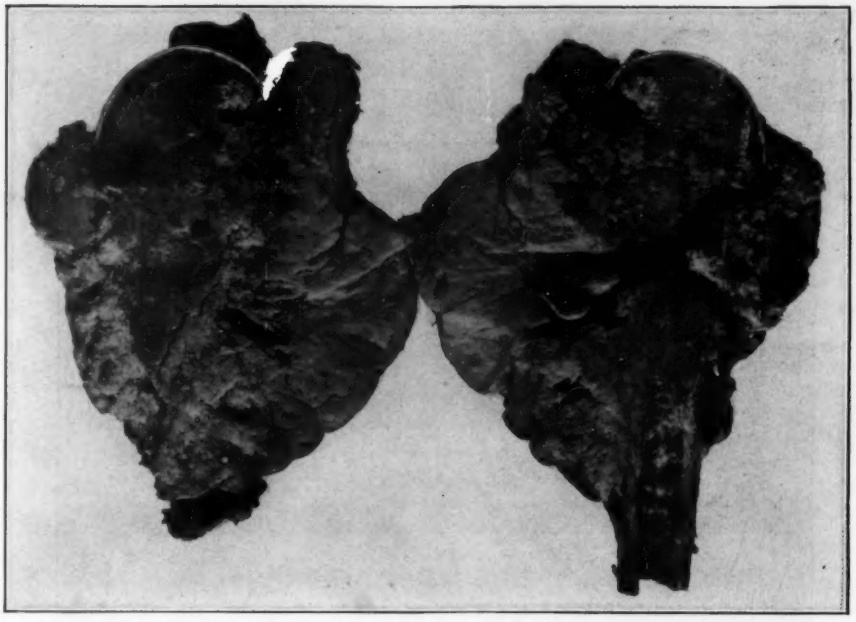

Fig. 77. Path. No. 14817 (IX). Photograph of gross specimen in case shown in Fig. 76. White male aged twenty-one; pain and swelling five months.

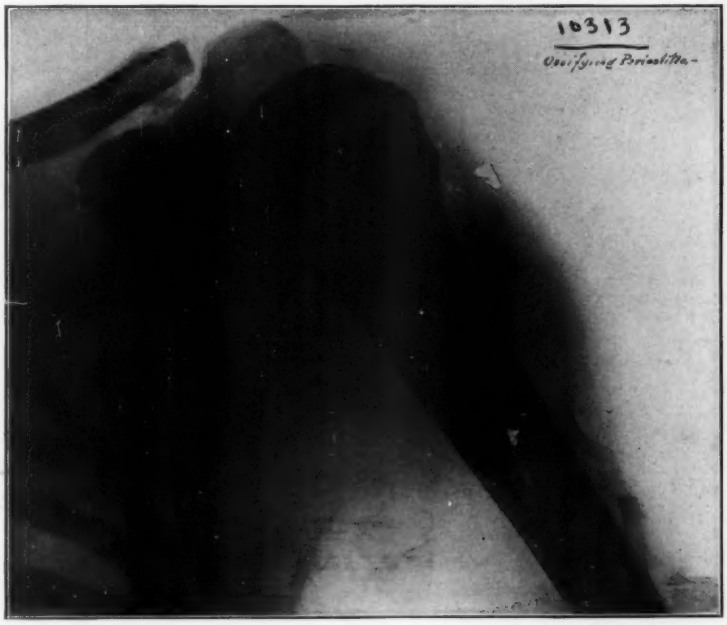

Fig. 78. Path. No. 10313. Traumatic ossifying periostitis of shaft of humerus and clavicle. Diagnosed periosteal sarcoma. See page 202.

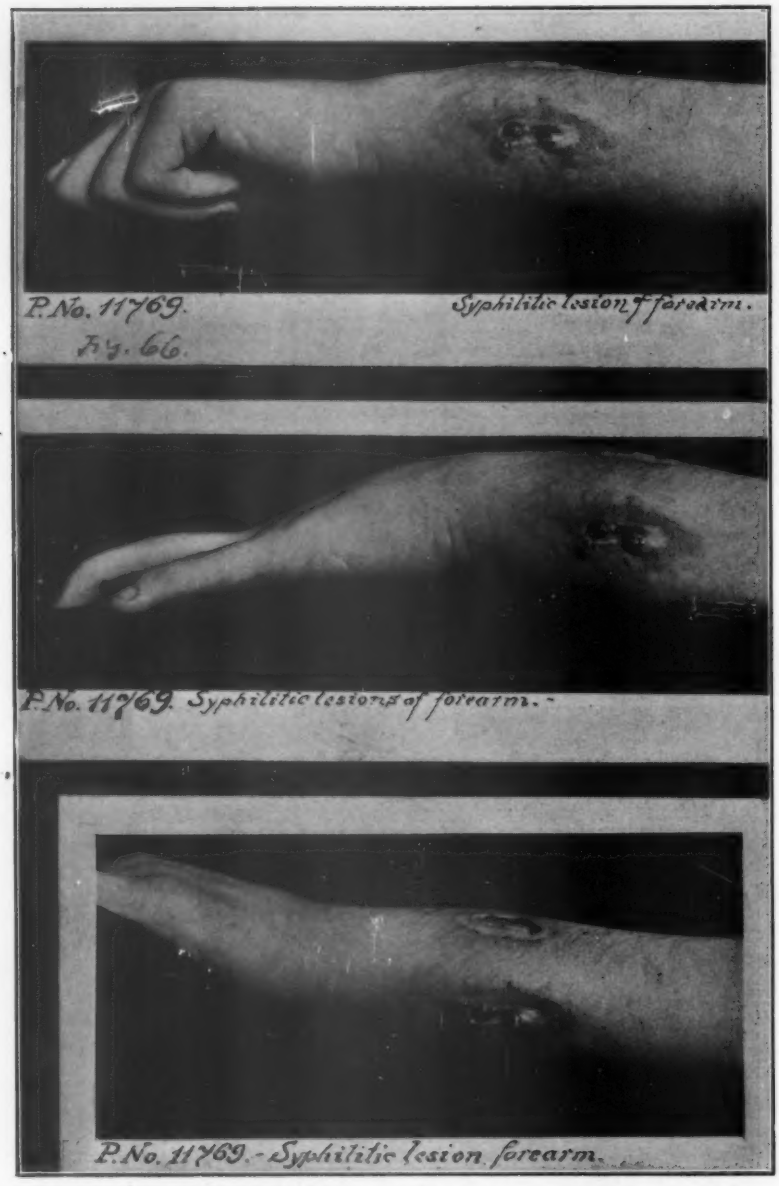

Fig. 79. Path. No. 11769. Syphilitic periostitis of lower end of ulna. For *x*-ray see Fig. 80. Diagnosed sarcoma. See page 204.

Fig. 80. Path. No. 11769. Syphilitic periostitis of lower end of ulna. Diagnosed sarcoma. See Fig. 79.

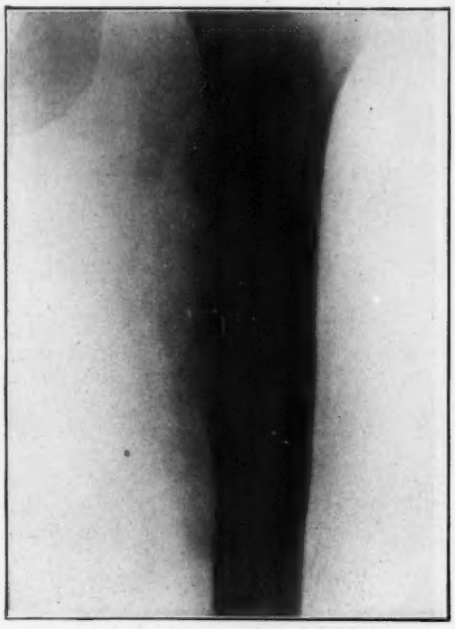

Fig. 81. Path. No. 16865. Infectious ossifying periostitis of upper shaft of femur. Diagnosed periosteal sarcoma. Refused operation. Recovery. For result see Fig 82, and page 205.

Fig. 82. Path. No. 16865. Result in case shown in Fig. 81.

Fig. 83. JCB No. 8415. Subacute osteomyelitis of ulna, suggesting periosteal sarcoma or syphilis. Compare with Figs. 73 and 80. See page 207.

Fig. 84. Path. No. 24311. Tuberculosis of metacarpo-carpal joint with ossifying periostitis of shaft of metacarpus. See page 207.

Fig. 85. Path. No. 24367. Bone formation in joint capsule associated with enchondroma of joint. See page 208.

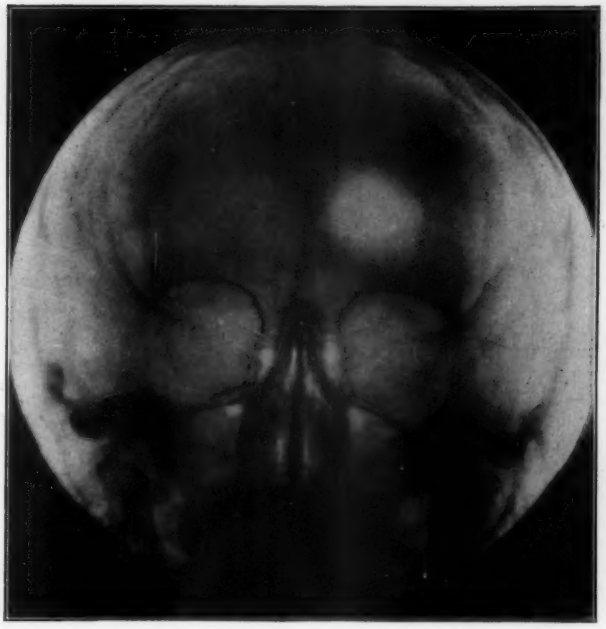

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Fig. 87. Path. No. 25888. Periosteal sarcoma of lower end of femur with much bone destruction and early metastasis to lung (see Fig. 88 and page 148.

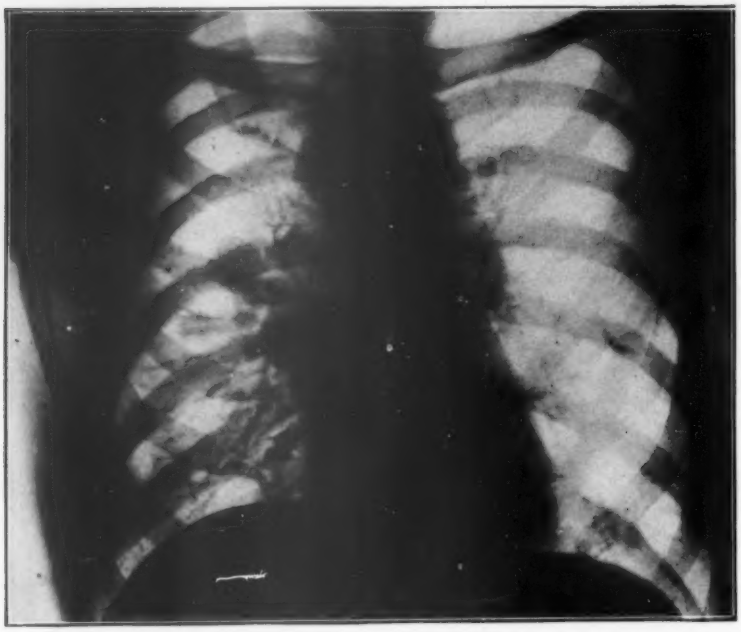

Fig. 88. Path. No. 25888. *X*-ray of chest showing metastasis from periosteal sarcoma of femur, shown in Fig. 87. See page 148.

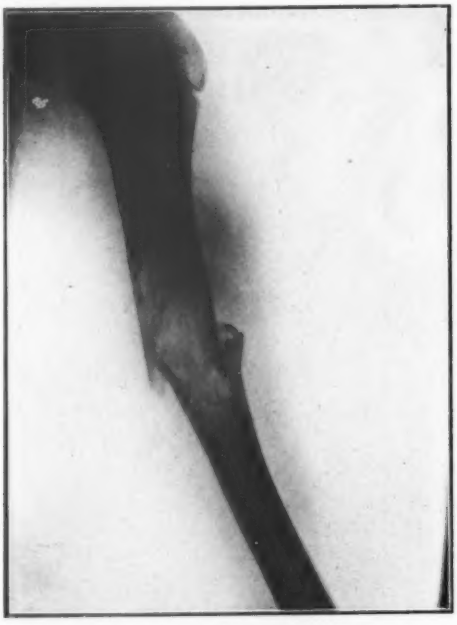

Fig. 89. Path. No. 25656 (III). Benign Central Solid Ostitis Fibrosa, shaft of humerus, pathological fracture. See text, page 161. Compare with Fig. 32, Path. No. 24096. Similar type of tumor shaft of tibia, no fracture. See text, page 163.

THE BONE NUMBER

Volume One, Number Three, of the JOURNAL OF RADIOLOGY, appearing with this issue, contains a most valuable contribution.

"The Diagnosis and Treatment of Benign and Malignant Tumors of Bone," by Joseph Colt Bloodgood, M. D., Professor of Surgery, Johns Hopkins University, Baltimore, comprises the entire number.

This paper deals with a subject that at the present time is under much discussion by pathologists and surgeons, and Dr. Bloodgood's work has gone far in clearing the atmosphere and gives us an excellent conception of bone tumors.

This contribution will be found to be of the greatest value to every medical man, be he surgeon, pathologist, roentgenologist, or internist. It should be read most carefully.

It is the intention to publish in another number within the very near future the end results obtained in the diseases dealt with in this paper.

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